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Design Analysis Cover Sheet

Complete only applicable items.

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11. REMARKS

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CONTENTS

TABLES

1. PURPOSE

The purpose of this design analysis is to update the conceptual design of the secondary Waste Treatment Building (WTB). This design analysis includes an assessment of anticipated secondary waste volume generation rates, establishment of a low-level waste (LLW) handling capacity in the WTB, development of data to support the preparation of process flow diagrams (PFDs), and preparation of a material balance table outlining the flow and conditions of major process streams entering, within, and exiting the WTB. In addition, this design analysis will size major process lines in the WTB system. The previous WTB conceptual design was based on the predominant use of multi-purpose canisters (MPCs) as well as dry handling of transportation casks, MPCs, and disposal containers (DCs) in the Waste Handling Building (WHB). DCs are the sealed (welded) metallic containers used to package and dispose of high-level waste (HLW) at the Repository. MPCs are sealed metallic containers suitable for storage and handling of spent nuclear fuel (SNF). The current WHB design is based on the predominant use of dual-purpose canisters (DPCs) and wet handling lines within the WHB. DPCs are disposable metallic containers suitable for handling of uncanistered SNF. Dry handling lines are also included in the current WHB design to accommodate canistered waste (i.e., SNF and/or HLW packages). The primary impact of the WHB changes on the WTB conceptual design are anticipated to be an increase in floor area requiring washdown, an increase in the number of cask handling operations, and additional secondary solid wastes resultant from pool operations.

2. QUALITY ASSURANCE

The classification of permanent items described in QAP-2-3, *Classification of Permanent Items*, has not been performed for the Waste Treatment Systems and Facilities discussed in this analysis. However, the Waste Treatment Systems and Facilities are identified as "Q" in the project *Q-List* (Reference 5.5) by direct inclusion. Therefore, the items addressed in this analysis will be treated as Q items. An activity evaluation has been performed in accordance with QAP-2-0 and has determined that this analysis is subject to the requirements of the *Quality Assurance Requirements and Description* (QARD) (Reference 5.1) because they affect items on the Q-List. Therefore, as specified in NLP-3-18, this activity is subject to quality assurance (QA) controls. Although the activities associated with performing this work are not expected to affect the ability of any Q item to perform its intended safety function, the activities will affect the preliminary size, configuration, and cost of the Q items.

Although the results of this analysis will update the configuration of the secondary waste treatment systems, they will not be used directly for procurement, fabrication, or construction and are considered conceptual. Therefore, the formal TBV and TBD tracking system described in NLP-3-15, *To Be Verified (TBV) and To Be Determined (TBD) Monitoring System*, is not applicable. Any data from this analysis that is used as design input must be treated as unconfirmed (TBV) and tracked per NLP-3-15 prior to inclusion in documents supporting fabrication, procurement, or construction.

3. METHOD

A WTB conceptual design was prepared in fiscal 1995, and the results presented in the *WTB Interim Design Study*, Reference 5.10. The design was based on an assessment of waste volumes built up from analysis of potential waste production mechanisms within the WHB and support systems. As similar facilities do not currently exist, estimation of secondary waste volumes resulting from repository operations must be based on conservative and educated assumptions. This design analysis will utilize secondary waste estimation techniques from the previous report, and employ updated information regarding the WHB design to develop revised waste generation rates. As was done in the previous effort, secondary waste rates will be built up from cask processing rates, cask physical dimensions, assumed frequency of contamination, operating area washdown frequency, and other predictable recurring secondary waste producing operations. The WTB process configuration selected in the previous study will be employed. Following re-assessment of waste volumes, the WTB process configuration will be re-examined to rule out the existence of new conditions which might invalidate the previously selected plant configuration.

With the configuration confirmed, the waste volume estimate will be used to establish new design capacity information for major equipment, the PFDs will be updated and line sizing information added, and the material balance table will be updated to reflect the new material flows.

4. DESIGN INPUT

4.1 DESIGN PARAMETERS

4.1.1 The waste arrival and emplacement schedules used in the preparation of this design analysis are discussed as assumptions in Sections 4.3.18, 4.3.19, and 4.3.20.

4.2 CRITERIA

The design criteria listed below was derived from the *Repository Design Requirements Document* (RDRD) (Reference 5.2). This criteria is directly applicable to the design subject and is restated in terms of that portion of the criteria which is addressed within this analysis.

4.2.1 LLW treatment facilities shall be designed to process any low-level radioactive waste generated at the repository into a form suitable to permit safe disposal at the repository, or transportation and safe disposal at an alternative site. (RDRD 3.7.3.9.A)

4.2.2 The LLW treatment facilities shall be capable of receiving waste according to the schedule shown in Table 3-3 of the RDRD, Reference 5.2. (RDRD 3.2.1.2.B)

4.3 ASSUMPTIONS

Development of the waste treatment system conceptual design requires estimating the annual quantity of secondary wastes. Since a facility has not yet been designed or operated which handles the type and throughput of waste proposed for the repository, technical data defining the quantity of liquid and solid secondary wastes generated or the specific types of decontamination operations which would be required is not available. As a substitute for this historic information, the waste generation estimate in this report is based on a number of engineering assumptions intended to yield a realistic estimate of the waste rates likely to result from repository operations. The configuration of the waste treatment system is such that substantial increases in waste rates can be accommodated by increasing the number of WTB operating shifts or by using a commercial vendor to process the excess wastes. The assumptions which form the basis for the waste treatment system analysis are listed below:

4.3.1 The WTB will be designed to operate 235 days per year based on single shift operation. The processing equipment operates for 6 hours each day based on a 2-hour down period for daily start-up and shut-down.

4.3.2 The types of decontamination/washdown methods used and the type and quantity of waste generated from each are provided in Table 7.2-1. The quantities are expressed as a rate (gallons or pounds) per unit (items or square foot of surface area) and are based on typical decontamination sequences.

4.3.3 The receipt schedule for casks, DPCs, and HLW canisters and the emplacement schedule for DCs are as shown in Table 7.2-2. This data was extracted from the CDA (Reference 5.4). Table 7.2-2 also shows the estimated cask dimensions (Reference 5.12), and the estimated DC dimensions (Reference 5.9). DPC dimensions are conservatively assumed to equal the dimensions of casks used to transport the DPC.

4.3.4 The floor areas of the potentially contaminated spaces within the WHB and WTB are provided in Table 7.2-3 (Reference 5.6). The WTB washdown area is assumed to be 80% larger than the net operations area of the WTB described in the MGDS ACD (Reference 5.3). This adjustment is based on the anticipated increase in facility size due to the larger waste generation rates estimated in this analysis (refer to Table 7.3-1 for rate comparison).

4.3.5 The assumed annual quantities of waste generated from individual decontamination and washdown operations are shown on Table 7.2-4. This table also includes the basis for these quantities including: decontamination frequency (months between floor washdowns or percentage of casks and equipment requiring decontamination), surface areas for casks, DCs, DPCs, operating areas, yokes, tooling and DC handling collars; percentage of each item or area that is decontaminated, and type of decontamination process used. Although it is acknowledged that dry decontamination of DCs is preferred, water decontamination is retained in this waste volume estimate for conservation.

4.3.6 A design margin of 20% is applied to the calculated waste generation rates for sizing the treatment and packaging equipment to account for uncertainty in the estimated waste rates.

4.3.7 Little published quantitative information exists relative to the quantity of solid LLW generated from cask and fuel handling operations. Based on the very limited information available, the following unit solid waste generation rates appear to be reasonable.

- 20 Ft^3 of rags, paper, and plastic are generated per transportation cask handling operation (per Reference 5.7, p.II.D.5-4).
- 100 Ft^3/Yr. of rags, paper, and plastic are generated per waste handling operator and waste treatment technician. There are 100 such operators (per Reference 5.15 - 23 x 3 shifts for the WHB + 16 technicians for the WTB, rounded up).
- 70% of the compactible solid LLW waste is rags, paper, and plastic (Reference 5.8).

4.3.8 The quantity of non-compactible solid LLW from operations is 15 Ft^3 per transportation cask. (This unit rate is derived from adjustment of the rate in Assumption 4.3.6.)

4.3.9 The volume of ion-exchange resin produced at the repository is not expected to be significant compared to other solid LLW waste forms (i.e., ~4%). In order to estimate the size of the WTB ion-exchange equipment and the resin packaging equipment, annual resin consumption was estimated based on engineering judgement as follows: 2,245 Ft^3 for the pool water treatment system in the WHB, and 85 Ft^3 for the LLW treatment system in the WTB. (These are dewatered resin volumes.)

4.3.10 The following batch transfer times have been selected for operations within the WTB. These times have been selected after an examination of operational sequences for daily batch operations and are predicated on the use of a single shift, 6 hour/ day batch operating mode.

Stream	Transfer Route	Time	Notes
107	From RH-TK-101 to RH-TK-108	30 min	~300 gals/batch
108	From RH-TK-102 to RH-FLT-101 A/B	60 min	1 batch/day, ~900 gals/batch
112	From RH-V-101 to RH-TK-108	10 min	~100 gals/batch
113	From RH-TK-104 to RH-TK-107A/B	180 min	~800 gals/batch thru Ion Exchange
115	From RH-DM-101 to RH-TK-106	15 min	~150 gals/batch, spent resin slurry
116	From RH-TK-108 to RH-ME-103	90 min	~300 gals/batch
119	From RH-ME-204 to RH-TK-102	60 min	~2000 gals/batch, spent resin slurry
105	From RH-TK-109 to RH-TK-101	120 min	~1000 gals/tank
-	From RH-PU-107 to users	120 min	~1336 gals/batch
-	From RH-PU-110 to RH-TK-101 or RH-TK-102	120 min	
-	From RH-TK-105 to RH-DM-101 A/B	30 min	

4.3.11 The collection tank sizes are based on the hold-up accumulation times and/or number of batch transfers as listed below. The calculated size was then rounded up to provide a conservative nominal tank capacity. The holdup times have been selected based on the ability to meet operational demands, and are deemed to be reasonable. The large holdup capacity in both the chemical and recyclable collection tanks is provided to provide the ability to accommodate large swings in waste rates.

Tank	Function	Hold-up Time
RH-TK-101	Chemical LLW collection	1 month
RH-TK-102	Recyclable LLW collection	1 month
RH-TK-103	Evaporator feed	1 day
RH-TK-104	Condensate collection	1 day
RH-TK-107A/B	Recycle water storage	1 week each
RH-TK-105	Resin feed tank	30 min
RH-TK-108	pH adjustment tank	1 day
RH-TK-109	WTB floor drain collection	6 weeks

4.3.12 The following assumptions are used to size the recycled liquid LLW evaporator: evaporation is operated for 3.5 hours each day, 90% of the feed exits as condensate, operating pressure is ambient, feed water temperature is 70°F, bottoms are allowed to cool to 130°F before exiting, and overhead is condensed to 10°F above the maximum cooling water temperature of 97°F. The 3.5 hour evaporation time is selected to yield a reasonable operating time in the 6-hour operating day, with allowance for heat-up and cool down. The evaporator overhead rate of 90% was selected as a reasonable level of bottoms concentration (i.e., lesser concentration would produce more waste and less recyclable condensate; higher concentration might present operating problems in the evaporator). Given the likelihood of relatively clean feed to the evaporator, 90% overhead is a reasonable assumption.

4.3.13 The following assumptions are used to design the recycled liquid LLW ion exchanger: the annual resin consumption is 85 Ft^3, the dewatered resin contains 58.7 wt% water and has a density of 32.5 lbs/ Ft^3, resin slurry of 10 wt% solids with a density of 50 lbs/Ft^3 is used for resin transfer, and resin beds are replaced once a month and spent dewatered resin acts as filler only in the grouting process.

4.3.14 The following assumptions are used to design the solid LLW grouting and compaction equipment: the ratio of liquid to Portland cement used for grouting is 0.45; the density of non-compacted, compacted and super-compacted waste is 10 lbs/ Ft^3, 40 lbs/Ft^3, and 150 lbs/Ft^3, respectively; 80% of drum volume is usable; supercompaction can achieve a volume reduction of 70%.

4.3.15 Adequate shielding will be provided for solid waste by loading one 55-gallon drum or 3 super-compacted 55-gallon drums in an 85-gallon overpack, and filling 90% of the annulus between the drums with grout that has a density of 196 lbs/Ft^3. (Reference 5.13, p. 3-90, Table 3-120.)

4.3.16 Economic line sizes are based on the fluid properties and velocities shown in Table 7.6-1. (This line sizing information is from Reference 5.13, p. 5-32, Table 5-17.) The minimum line size is 1 inch.

4.3.17 The following stream density values are assumed for this conceptual design effort as representative (These density values are based on adjustment of the base density of water near ambient conditions of 62.4 Lb/Ft^3.):

Stream No.	Density (Lb/Ft^3.)
101	66.5
104, 106, 107	64.0
105	66.5
109	65.3
111	62.4
112	80.9
119	62.4

4.3.18 Waste receiving and emplacement schedules described in the CDA Assumptions Key 001 and Key 003 meet the requirements of RDRD Table 3-3 based on the CDA (Reference 5.4), Assumption Identifier: RDRD 3.2.1.2B

4.3.19 The transportation cask truck and rail waste arrival schedule is based on the CDA (Reference 5.4) Tables 3-1, 3-2, and 3-3, Assumption Identifier: Key 001, Subject: Cask Arrival Scenario.

4.3.20 The waste package emplacement schedule is based on the CDA (Reference 5.4), Table 3-9, Key 003, Subject: Waste Package Emplacement Scenario.

4.3.21 Significant quantities of secondary mixed or low-level radioactive wastes will not be generated by underground emplacement operations based on the CDA (Reference 5.4), Assumption Identifier: DCS 011, Subject: Underground Waste Generation.

4.3.22 Waste quantities generated by the performance confirmation operations will be negligible and will not impact the design of the WTB based on the CDA (Reference 5.4), Assumption Identifier: DCS 013, Subject: Waste Generaged by Performance Confirmation Activities.

4.4 CODES AND STANDARDS

None used in this analysis.

5. REFERENCES

5.1 *Quality Assurance Requirements and Description* (QARD), U. S. Department of Energy, DOE/RW-0333P, REV 7.

5.2 *Repository Design Requirements Document* (RDRD), Yucca Mountain Site Characterization Project, YMP/CM-0023, REV 0, ICN 1.

5.3 *Mined Geological Disposal System* (MGDS), Advanced Conceptual Design Report (ACD), M&O Document Identifier B00000000-01717-5705-00027, REV 00.

5.4 *Controlled Design Assumptions Document* (CDA), M&O Document Identifier B00000000-01717-4600-00032, REV 04, ICN 1.

5.5 *Q-List,* U.S. Department of Energy, YMP/90-55Q, REV 4.

5.6 Interoffice Correspondence, Decontamination Floor Areas, S. J. Meyers to S. H. McFeely, LV.SD.SJM.5/97-017, May 30, 1997.

5.7 *Multi-purpose Canister Implementation Program Conceptual Design Phase Report, Volume II.D - MPC Utility Transfer System* (UTS) *Conceptual Design Report*, September 30, 1993.

5.8 *Advanced Radioactive Waste Compaction Techniques*, Electric Power Research Institute (EPRI), NP-5838, August 1988.

5.9 Interoffice Correspondence, Report on Preliminary Design of Waste Package Emplacement Support Structure (Revision: Added Support Spacing), H. A. Benton to K. Bhattacharyya, LV.WP.SMB.05/97-086-A, May 28, 1997.

5.10 *Waste Treatment Building Interim Design Study for FY 1995*, Document Identifier:BCB00000-01717-5705-00007, Rev.00, September 28, 1995.

5.11 *Transportation Cask Contamination Weeping; A Program Leading to Prevention*, Bennet, P.C., D. H. Doughty, W. B. Chambers, Sandia National Laboratories, 1993.

5.12 Interoffice Correspondence, Transportation Cask Dimensions, S.J. Meyers to S. H. McFeely, LV.SD.SJM.6/97.021, June 17,1997.

5.13 *Chemical Engineers' Handbook*, Fifth Edition, Perry, Robert H. and Cecil H. Chilton, ed., McGraw-Hill Book Co., 1973.

5.14 *Chemical Engineers' Handbook*, Fourth Edition, Perry, Robert H. and Cecil H. Chilton, ed., McGraw-Hill Book Co., 1963.

5.15 Interoffice Correspondence, Transmittal of Repository Operations Staffing Letter Report, Deliverable RP242CM, WBS 1.2.4.6, R. O. Snell to Dr. Stephen J. Brocoum, L.V.SD.SJM.1/96.098, December 31, 1996.

5.16 *Phosphate/Sulfate Waste Grout Campaign Report*, Cline, M.W., A.R. Tedeschi and A.K. Yoakum, Westinghouse Hanford Company, Abstract from Waste Management Symposium, Volume I, 1990.

6. USE OF COMPUTER SOFTWARE

Lotus Development Corporation's commercial LOTUS 1-2-3, Revision 5 spreadsheet software will be used as a computational tool for preparation of the secondary waste generation rate estimate, as well as for the sizing of major process lines.

7. DESIGN ANALYSIS

7.1 INTRODUCTION

A waste repository has not yet been designed, constructed, or operated. Consequently, historic data defining the types and volumes of secondary waste generation is unavailable. The first task in this design analysis, documented in Section 7.2, will be to develop a secondary waste generation rate estimate based on available information on operations performed within the industry similar to those at the repository, and on the type, frequency, and speculated rate of decontamination of materials received or processed at the repository.

Following development of the waste generation rate estimate, the existing conceptual design of the waste treatment system will be re-evaluated to identify the effects, if any, of waste rate changes. The results of this re-valuation process are discussed in Section 7.3.

Section 7.4 of this report addresses development of the stream data necessary for preparation of the material balance table included as part of, and keyed to, the PFDs. This table identifies major material flows of streams in the waste treatment system, as well as the condition of these streams.

Section 7.5 of this analysis addresses waste treatment system equipment sizing. The size of major processing equipment in the waste treatment system is based primarily on the waste rate estimate. In this section, the capacity requirements of major equipment are developed. This equipment capacity information will be included on updated PFDs.

The last section of this design analysis, Section 7.6, addresses the sizing of major process lines in the waste treatment system. The line sizes developed in the section appear on the PFDs.

It is anticipated that the following secondary LLW streams will be produced as a result of Repository operations.

Liquid Streams

Recyclable Liquids - Aqueous streams suitable for treatment and recycling.

- Decontamination water
- Floor washdown water

Chemical Liquids - Aqueous streams unsuitable for treatment and recycling due to chemical content.

- Spent decontamination solution
- Floor washdown water

Solid Streams

- Compactible solid wastes (rags, paper, plastic, etc.)
- Non-compactible solid wastes (metal, wood, etc.)
- Spent ion-exchange resin (slurry)

All of the above streams, with the exception of recyclable liquid, are grouted and disposed of.

Typical items to be decontaminated include:

- Arriving Truck/ Rail Carriages
- Loaded Casks
- Unloaded Casks
- Unloaded Dual-Purpose Canisters
- Facility Floors
- Disposal Containers
- Small Equipment & Tools
- Crane Hooks, Casks, Cask Lids, Vacuum Equipment, and other items exiting the Assembly Handling Pools

All calculations in this section of this report will be rounded to three significant digits for final presentation.

7.2 SECONDARY WASTE GENERATION RATE ESTIMATE

The WTB will be sized to handle the maximum annual secondary waste generation rate associated with normal operations, with provision for higher rates associated with upset conditions. (Secondary wastes are commonly defined as those radioactive wastes generated or created during the processing of SNF.) The maximum annual secondary waste generation rate will be determined from an examination of repository waste receipt rates as well as the rate of repository waste package processing. Since a facility has not been built which processes the types and quantities of HLW proposed for the repository, detailed data supporting the rate of secondary waste generation is not available. As a substitute for actual plant operating data, the rate estimate for the repository will be built up from a significant number of assumed or estimated parameters such as the rate of receipt of contaminated transportation casks, methods of decontamination to be employed and quantities of decontamination materials required, frequency and fluid volumes used for facility floor washdown, ion-exchange resin, high-efficiency particulate air (HEPA) filter and cartridge filter quantities and replacement intervals, and other supporting data. The objective in establishing the waste rate estimate is to develop a reasonable basis for facility conceptual design. The assumptions used to support the rate estimate are defined in Section 4.3 of this report.

The primary generator of secondary liquid LLW is anticipated to be decontamination and washdown operations performed within the repository surface facilities in general and the WHB in particular.

The liquid LLW treatment system presented in this design analysis is based on the previous study, the *WTB Interim Design Study*, Reference 5.10, and consists of two primary processing systems: 1) generated liquid waste streams which contain chemicals and which are unsuitable for recycling are grouted and disposed of as solid waste, and 2) those liquid waste streams suitable for recycling are treated in a series of processing steps including filtration, evaporation, and ion-exchange, and are recycled for further use. This recycling of waste water represents a significant reduction in water demand by the repository facilities, as well as a major reduction in waste water disposal requirements.

To prepare a waste volume estimate it is necessary to define, at least conceptually, the decontamination operations to be utilized, the frequency of these operations, and the volume of waste fluids generated at each step of each operation. For reasons previously stated, it is necessary to employ educated assumptions regarding the decontamination and washdown techniques employed and the secondary wastes generated. For the purposes of this conceptual design, for aqueous decontamination of major equipment, excluding unsealed waste packages, and decontamination operations performed remotely, a two stage hands-on decontamination system is proposed consisting of increasingly severe measures. This stepwise approach is generally accepted as industry practice. The first step in this process is wiping or swiping of detected contamination areas on subject equipment. This wiping might include the use of spray bottles containing detergent or other chemical decontamination solutions on a small scale. The generation of liquid waste streams from this type of decontamination is not anticipated. Assuming that this procedure is ineffective in removing the contamination, the next approach consists of a more comprehensive washdown with an aqueous solution containing specialized chemicals or citric acid. This decontamination begins with water washing, followed by application of the chemical solution and completed by a water rinse. This technique would result in the generation of a chemical waste stream presumed to be unsuitable for recycle. A modified version of this procedure would be employed in areas requiring remote operations.

Other types of decontamination procedures to be employed for specialized decontamination will include hands-on washdown of components exiting the fuel handling pools with demineralized water, remote blasting with pelletized solid CO_2 where the use of water is undesirable, and remote spraying of components with recycle water or chemical solution. Spray down with demineralized water would be performed above the assembly handling pools, with the waste water stream entering the pool system. The pool water treatment system, in turn, processes this water stream.

The pelletized CO_2 decontamination system is the system of choice for decontamination of loaded but unsealed DCs, as this technique avoids the introduction of water to the DCs. The sublimed CO_2, along with any entrained contamination, is removed via a vacuum system equipped with HEPA filtration. Any solid contamination not entrained in the gas (CO_2) stream will ultimately wind up on the floor of the decontamination cell where it is removed during periodic floor washdown. The aqueous waste streams resulting from this floor washdown will be routed to either the pool system in the WHB or to the WTB, depending on the level of radiological activity.

The estimated quantities of secondary wastes generated as a result of application of each of these decontamination procedures are listed in Table 7.2-1.

Table 7.2-1
Waste Generation by Decontamination/Washdown Method

Decontamination Method	Type	Wipe (Solid) Lbs/100 Ft^2	Aqueous (Pool) Gal/100 Ft^2	Aqueous Recycle Gal/100 Ft^2	Chemical Recycle Gal/100 Ft^2	Dry CO_2 (Solid) Lbs/Item
Small Scale Wipe Decon						
Rags	Solid	2.5	-	-	-	-
Swipes	Solid	2.5	-	-	-	-
Chemical/Detergent Decon.						
Detergent/Chemical	Chemical	-	-	-	16	-
Water Rinse	Aqueous	-	-	24	-	-
Rinse Rags	Solid	1	-	-	-	-
Chemical Rags	Solid	1	-	-	-	-
Above Pool Decon.						
Demin. Water	Aqueous	-	20	-	-	-
Special Decon.(Pelletized CO_2)						
Solid CO_2	Solid	-	-	-	-	2

A significant quantity of secondary waste is generated as a result of decontamination of transportation casks and waste packages. The volume of waste produced in these operations can be expressed as a function of the exterior surface area to be decontaminated, and varies with the annual throughput of these items during the emplacement period of repository operations. The annual exterior surface area of transportation casks, DPCs, and DCs processed in any particular year of emplacement operations can be calculated by combining the cask delivery data and cask dimensional data. The following is an example calculation of the area of HLW canisters delivered in the year 2015:

The transportation casks and DCs approximate right circular cylinders. From Reference 5.13, p. 2-6, the area of a circle is $\pi D^2 / 4$. The area of the lateral surface of a right circular cylinder is, from Reference 5.13, p. 2-7, 2π (radius)(altitude). Therefore, the area of a right circular cylinder is:

$2(\pi D^2 / 4) + 2\pi$ (R)(h) where R and h are the radius and height, respectively.

From Reference 5.4, there are 159 of these canisters delivered in the year 2015. From Reference 5.12, these casks are 85 inches in diameter and 212 inches in length. Now 1 foot is equal to 12 inches. Therefore, the cask dimensions in feet are:

$D = 85/12 = 7.1$ Ft $\quad h = 212 / 12 = 17.7$ Ft

The area of one cask is:

$$2\,(\pi)(7.1)^2 / 4 + 2\,(\pi)(7.1 / 2)(17.7) = 471.7 \text{ Ft}^2$$

The total surface area of these casks arriving in 2015, then, is:

$159 * 471.7 = 75{,}002 \text{ Ft}^2$.

The cask and DC processing schedules are taken from the CDA, Reference 5.4, and the exterior dimensions are from Reference 5.12 for casks and Reference 5.9 for DCs. Table 7.2-2 summarizes the results of spreadsheet calculations of the surface area of arriving casks and processed DCs for each year of emplacement operations. The abbreviations used in Table 7.2-2 are taken directly from the CDA, Reference 5.4. From Table 7.2-2, the maximum surface area of transportation casks and DCs processed occurs in the year 2026, and is approximately 459,000 Ft^2 for casks and DPCs and 190,000 Ft^2 for DCs. These areas form the basis for maximum waste rates related to processing of casks and DCs.

Canistered fuel accounts for the majority of cask arrivals in the year 2026, at 410. (See Table 7.2-2 and Assumption 4.3.3. These casks are represented as DPCs, and are processed in the wet handing lines of the WHB. Using the surface area of arriving canistered fuel transportation casks as a measure of DPC surface area, from Table 7.2-2, the exterior surface area of DPCs processed in 2026 is about 187,000 Ft^2.

Table 7.2-2
Annual Surface Area of Casks Processed

YEAR/Cask Type	TRUCK								
Cask I.D:	GEN	GEN	GEN	GEN	HH	HH	HH SS		TOTAL
Fuel Capacity:	9 BWR	7 BWR	4 PWR	3 PWR	7 BWR	3 PWR	3 PWR		
Cask L (In):	198.0	227.0	188.0	218.0	227.0	218.0	218.0		
Cask Dia. (In):	47.0	68.0	48.0	68.0	68.0	68.0	68.0	Total	
Area (Ft2):	227.0	387.0	221.9	373.7	387.0	373.7	373.7	Area (Ft2)	
2010	17	0	17	0	0	0	0	7,631	34
2011	14	0	0	0	1	0	16	9,544	31
2012	14	0	11	0	0	0	0	5,619	25
2013	18	0	54	0	0	0	0	16,068	72
2014	7	1	67	0	0	25	0	26,184	100
2015	24	1	31	0	0	26	2	23,176	84
2016	23	3	62	7	0	27	11	36,954	133
2017	6	13	20	29	3	11	17	33,291	99
2018	4	31	31	0	0	29	0	30,620	95
2019	4	30	44	18	2	14	18	41,738	130
2020	36	0	38	36	3	22	0	39,437	135
2021	16	0	30	0	1	7	19	20,391	73
2022	21	0	22	39	3	18	14	37,340	117
2023	28	0	12	24	1	31	47	47,519	143
2024	30	29	53	15	1	5	0	37,654	133
2025	13	0	23	10	4	30	0	24,549	80
2026	0	0	0	0	0	0	0	0	0
2027	0	0	0	0	0	0	0	0	0
2028	0	0	0	0	0	0	0	0	0
2029	0	0	0	0	0	0	0	0	0
2030	0	0	0	0	0	0	0	0	0
2031	0	0	0	0	0	0	0	0	0
2032	0	0	0	0	0	0	0	0	0
2033	0	0	0	0	0	0	0	0	0
Total:	275	108	515	178	19	245	144	437,717	1,484

YEAR/Cask Type	UCF											
Cask I.D:	LG GEN	LG GEN	SM GEN	SM GEN	HH	HH	HH SS	HH SS	LG GEN	LG ST		TOTAL
Fuel Capacity:	61 BWR	26 PWR	24BWR	24 PWR	17 BWR	7 PWR	17 BWR	7 PWR	44 BP	12 PWR		
Cask L (In):	210.0	193.0	205.0	205.0	210.0	210.0	210.0	210.0	181.0	205.0		
Cask Dia. (In):	92.0	99.0	96.0	96.0	64.0	64.0	64.0	64.0	94.0	96.0	Total	
Area (Ft2):	513.6	523.5	529.6	529.6	337.7	337.7	337.7	337.7	467.3	529.6	Area (Ft2)	
2010	0	0	0	0	0	0	0	0	0	0	0	0
2011	4	16	38	12	1	12	0	0	0	0	41,301	83
2012	16	33	69	48	0	10	0	0	0	5	93,482	181
2013	30	52	71	77	0	0	0	0	0	10	126,308	240
2014	42	95	96	141	0	20	0	0	0	0	203,575	394
2015	44	91	113	98	1	29	0	0	0	10	197,411	386
2016	34	91	81	120	1	19	0	0	0	12	184,662	358
2017	39	93	93	85	6	57	0	0	0	5	186,910	378
2018	38	97	67	71	2	48	0	0	1	6	163,913	330
2019	33	81	76	67	1	60	0	0	0	12	162,042	330
2020	31	78	45	43	2	33	0	0	0	5	117,828	237
2021	30	68	41	39	2	71	0	0	0	11	123,853	262
2022	36	69	25	16	0	17	0	0	0	16	90,539	179
2023	23	62	15	23	5	30	0	0	0	5	78,863	163
2024	26	36	39	19	5	32	0	0	0	4	77,530	161
2025	32	66	33	15	5	37	0	0	0	5	93,239	193
2026	9	8	0	0	0	0	3	0	0	0	9,823	20
2027	2	27	0	0	0	0	3	27	0	0	25,293	59
2028	5	22	0	0	0	0	1	17	0	0	20,164	45
2029	2	12	0	0	0	0	3	7	0	0	10,686	24
2030	9	21	0	0	0	0	6	15	0	0	22,708	51
2031	6	37	0	0	0	0	0	0	0	0	22,451	43
2032	92	164	0	0	0	0	0	15	0	20	148,760	291
2033	41	124	0	0	0	0	0	16	0	0	91,373	181
Total:	624	1,443	902	874	31	475	16	97	1	126	2,292,714	4,589

Table 7.2-2, Continued
Annual Surface Area of Casks Processed

YEAR/Cask Type	CF RAIL									TOTAL	HLW	TOTAL		TOTAL IN	WASTE PACKAGES					TOTAL OUT	TOTAL CASK AREA (Ft2) *	TOTAL WP AREA (Ft2)
Cask I.D:	LG CN	LG CN	MED C	MED C	SM CAN	SM CAN	LG SS	LG CN							LG WP	LG WP	SM WP	HLW				
Fuel Capacity:	61 BWR	24 PWR	44 BWR	21 PWR	24 BWR	12 PWR	24 PWR	44 BP							44 BWR	21 PWR	12 PWR	4				
Cask L (In):	210.0	203.0	210.0	210.0	210.0	210.0	210.0	210.0			212.0				210.0	210.0	210.0	149.2				
Cask Dia. (In):	92.0	96.0	91.0	91.0	71.0	71.0	92.0	92.0	Total		85.0				63.1	65.0	51.1	77.5	Total			
Area (Ft2):	513.6	525.4	507.0	507.0	380.1	380.1	513.6	513.6	Area (Ft2)		471.7		Area (Ft2)		332.4	343.7	262.5	317.6	Area (Ft2)			
2010	5	10	3	7	0	0	0	0	12,892	25	0	0	0	59	13	21	1	0	11,801	35	33,415	11,801
2011	0	7	0	0	0	0	0	0	3,678	7	0	0	0	121	30	40	2	0	24,244	72	58,201	24,244
2012	0	2	0	0	6	0	0	0	3,331	8	0	0	0	214	65	74	5	0	48,350	144	105,764	48,350
2013	0	9	0	2	8	0	7	0	12,378	26	0	0	0	338	89	134	18	0	80,361	241	167,133	80,361
2014	0	1	5	7	0	3	0	1	8,263	17	0	0	0	511	118	211	38	0	121,715	367	246,285	121,715
2015	1	3	8	8	8	3	0	1	14,896	32	159	159	75,002	661	142	186	37	199	184,043	564	325,382	184,043
2016	0	3	9	13	7	8	0	0	18,431	40	161	161	75,945	692	110	203	53	202	184,403	568	334,423	184,403
2017	3	2	4	15	18	8	0	0	22,106	50	160	160	75,473	687	129	190	56	200	186,401	575	339,887	186,401
2018	0	5	14	18	34	7	0	2	35,461	80	160	160	75,473	665	131	189	51	200	185,410	571	340,929	185,410
2019	4	8	14	24	24	7	0	0	37,306	81	159	159	75,002	700	126	179	70	199	184,980	574	353,394	184,980
2020	10	20	14	40	48	4	0	0	62,786	136	160	160	75,473	668	130	186	53	200	184,571	569	358,310	184,571
2021	4	30	16	42	48	14	0	0	70,788	154	160	160	75,473	649	116	193	65	200	185,474	574	361,293	185,474
2022	4	18	35	44	82	14	0	0	88,052	197	160	160	75,473	653	154	167	53	200	186,018	574	379,456	186,018
2023	9	34	32	67	40	16	0	0	93,963	198	161	161	75,945	665	114	197	66	202	187,082	579	390,253	187,082
2024	11	30	57	56	61	19	0	0	109,108	234	160	160	75,473	688	173	155	46	200	186,371	574	408,875	186,371
2025	11	33	15	52	69	10	5	1	90,064	196	160	160	75,473	629	136	177	69	200	187,672	582	373,390	187,672
2026	32	51	55	68	144	31	29	0	186,998	410	159	159	75,002	589	189	185	0	199	189,609	573	458,821	189,609
2027	18	37	55	103	134	24	4	2	171,924	377	160	160	75,473	596	158	205	0	200	186,497	563	444,614	186,497
2028	27	52	59	100	83	19	1	0	161,082	341	160	160	75,473	546	150	204	0	200	183,495	554	417,801	183,495
2029	31	75	48	97	78	14	0	1	164,322	344	160	160	75,473	528	138	208	0	200	180,881	546	414,804	180,881
2030	45	71	23	90	80	15	2	1	155,354	327	37	37	17,453	415	146	214	0	47	137,006	407	350,869	137,006
2031	41	87	23	72	47	25	3	1	144,352	299	87	87	41,039	429	115	234	0	109	153,270	458	352,194	153,270
2032	0	3	0	0	0	0	0	1	2,090	4	83	83	39,152	378	129	224	0	102	152,262	455	192,091	152,262
2033	0	0	0	2	0	0	0	0	1,014	2	0	0	0	183	58	161	0	0	74,614	219	93,401	74,614
Total:	256	591	489	927	1,019	241	51	11	1,670,642	3,585	2,606	2,606	1,229,273	12,264	2,859	4,137	683	3,259	3,586,529	10,938		
																					MAX 458,821	MAX 189,609

* Includes twice the area of DPCs, since casks containing DPCs are decontaminated as well as the DPCs themselves.

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Washdown of WHB and WTB floor areas produces a significant amount of secondary waste which will require treatment. Table 7.2-3 identifies the calculated floor areas of major areas of the WHB, as well as the WTB, which are assumed to require periodic washdown. The dimensions of the WHB and WTB floor areas used in this computation are from Reference 5.6.

Table 7.2-3
WHB and WTB Floor Areas

Area	Number of Spaces	Square Footage
WHB Decon Washdown		
Assembly Transfer Lines:		
Cask Prep	3	4,800
Pool/Pool Equipment	4	12,000
Assembly Cell	3	5,100
DC Load/Decon	3	4,500
Canister Transfer Lines	2	6,000
DC Cell	2	22,500
WP Decon	1	1,800
Hot Support	5	30,600
WHB Total		**87,300**
WTB		
WTB Total	1	**25,000**

Waste Generation Calculation:

A sample hand calculation will be performed to demonstrate the method used to prepare the waste generation rate estimate. This calculation was repeated using a spreadsheet to develop secondary waste generation rate estimates for the primary waste generators, which are decontamination and floor washdown operations. The results of the spreadsheet calculations are presented in Table 7.2-4. Major assumptions used to support the rate estimates are detailed in Section 4.3 of this report. A margin of 20% has been applied to the calculated waste rates, for conservatism, given the conceptual nature of the WHB design.

Example Calculation: Waste Generated in Decontaminating Outgoing Casks in the Assembly Transfer Lines.

The quantity of outgoing casks is 430. This number is derived from Table 7.2-2, and is the sum of uncanistered fuel (UCF) rail casks and canistered fuel (CF) rail casks received in the year 2026 (the emplacement year producing the largest cask surface area processed):

410 CF Rail Casks + 20 UCF Rail Casks = **430 Outgoing Casks**

The stated decontamination frequency of outgoing casks is 50%. Therefore, the surface area of these casks processed in one year is 50% of the total area processed annually. From Table 7.2-2, the total area processed in the year 2026 is 458,821 Ft^2. This area includes double the area of casks containing DPCs (to account for both DPC shipping casks and DPC overpacks). Subtracting the area of DPC overpacks (186,998 Ft^2), since these are accounted for separately in Table 7.2-4, , the area to be decontaminated is:

$$(458{,}821\ Ft^2 - 186{,}998\ Ft^2) * 50/100 = 136{,}000\ Ft^2$$

Now 80% of the decontaminated casks undergo recycle water decontamination and 20% undergo chemical decontamination. Further, 100% of the area of decontaminated casks is sprayed. 10% of the area of decontaminated casks is wiped. From Table 7.2-1, the quantity of solid waste produced from wipe decontamination is 5 Lbs/100 Ft^2 , from recycle water decontamination 1 Lb/100 Ft^2, from chemical decontamination 1 Lb/100 Ft^2, and from CO_2 decontamination 2 Lbs/100 Ft^2 (this solid waste is processed in the pool). Also from Table 7.2-1, the quantity of recyclable water produced in water decontamination is 24 Gal/ 100 Ft^2 and the quantity of chemical waste produced from chemical decontamination is 16 Lb/Ft^2.

The quantity of solid waste generated is:

136,000 Ft^2 / 100 * 10/100 (% Area Wiped) * 0 / 100% Wiped * 5 Lbs Solid/100 Ft^2
= 0 Solid Waste

136,000 Ft^2 / 100 * 100/100 (% Area Sprayed) * 80/100% Recycl. Decon. * 1 Lb Solid/ 100 Ft^2
= 1,090 Lb Solid Waste from Recyclable Wash

136,000 Ft^2 / 100 * 100/100 (% Area Sprayed) * 20/100% Chem. Decon. * 1 Lb Solid/ 100 Ft^2
= 272 Lb Solid Waste from Chem. Wash.

Therefore, the total solid waste from decontamination is: 0 + 1,090 +272 = **1,360 Lbs. Solid Waste**

The quantity of recyclable liquid waste generated is:

136,000 Ft^2 / 100 * 100/100% Area Sprayed * 80/100% Recyc. Decon * 24 Gal/ 100 Ft^2
= 26,100 Gal/Yr Recyclable Liquid Waste

The quantity of chemical liquid waste generated is:

136,000 Ft^2 / 100 * 100/100% Area Sprayed * 20/100% Chem. Decon * 16 Gal/ 100 Ft^2
= 4,350 Gal/Yr Chemical Liquid Waste

The numbers calculated above are in agreement with the spreadsheet, Table 7.2-4.

Explanation of Table 7.2-4:

The first column in the spreadsheet (Table 7.2-4), Area/ Item, identifies the area or item in the surface facilities subject to periodic washdown or decontamination operations. The second column, Quantity/ Year, indicates the quantity installed or units processed annually. The third and fourth columns, Decon Frequency (Mos) and (Units), indicate the decontamination (or washdown) frequency in months or percent of total units, respectively. Column five in the spreadsheet is the unit area of the item to be decontaminated in Ft^2/Unit, taken from either Table 7.2-3 or assumed per Assumption 4.3.5. Column six, Ft^2/Yr, is the calculated surface area processed on an annual basis, expressed as square feet per year. This column is the product of either the number of units multiplied by 12 divided by the decontamination frequency in months multiplied by the unit surface area or the product of the number of units multiplied by the percentage decontaminated annually multiplied by the unit surface area.

The seventh and eighth columns in the spreadsheet represent the percentage of surface area (column 6) decontaminated by wiping or spraying, respectively. Columns nine through thirteen indicate the percentage of decontamination by method. For example, it might be assumed that 80% of casks undergo wipe style decontamination, while 20% undergo decontamination using recycle water.

The last four columns in the spreadsheet show the calculated waste stream flow rates derived from decontamination or washdown operations. Column 14 shows the amount of solid waste. This waste is assumed to consist of rags and swipes resulting from small scale decontamination operations. Column 15 shows the estimated annual quantity of recyclable water waste derived from water wash operations, and column 16 shows the estimated amount of chemical liquid waste resulting from chemical decontamination/ washdown operations. Finally, column 17 shows the estimated quantity of demineralized water returned to the assembly handling pool(s) after use for washdown of equipment removed from the pool. Each of the these last four columns is calculated using the unit waste rates shown in Table 7.2-1.

Additional Solid LLW

In addition to the solid LLW generated as a result of decontamination and washdown operations, other solid LLWs are produced as a result of routine operations. The amount of this solid waste is estimated as follows:

With 20 Ft^3 of compactible solid waste (rags, paper, and plastic) generated for each cask handling operation (Assumption 4.3.7), 589 casks received in 2026, and one handling operation per cask, the amount of solid compactible LLW generated is:

$$20\ Ft^3/\ Op * 589\ Op/\ Yr = 11{,}800\ Ft^3/Yr$$

From Assumption 4.3.7, the quantity of compactible solid waste generated by plant operators is:

$$100\ Oper. * 100\ Ft^3/\ Oper. = 10{,}000\ Ft^3/Yr$$

Therefore, the total compactible solid LLW (paper, plastic, rags) generated is:

$$11{,}800\ Ft^3/Yr + 10{,}000\ Ft^3/Yr = 21{,}800\ Ft^3/Yr$$

Table 7.2-4
Secondary Waste Generation from Decontamination/Floor Washdown Operations

Area/Item	Qty/ Year	Decon. Freq. (Mos.)	(Units)	Ft2/ Unit	Ft2/ Year	Area Decon (%) Wiped	Spray	Type of Decon (%) Wipe	Water	Chem.	CO2	DM Water	Solid LLW(Lbs)	Liq.LLW (Gals) Rec. Liq	Chem. Liq.	Pool Water Rtn to Pool
Pre WHB																
Carriers	589		5%	400	11,780	10%	100%	80%	20%				71	565		
WHB Washdown																
Cask Prep	3	12		4,800	4,800		100%		60%	40%			48	691	307	
Assembly Transfer Lines																
Pool Areas	4	1		12,000	144,000		100%		60%	40%			1,440	20,736	9,216	
Assy Cell (dry)	3	0.5		5,100	122,400		100%		60%	40%			1,224	17,626	7,834	
DC Load/Decon	3	6		4,500	9,000		100%		60%	40%			90	1,296	576	
Canister Transfer Lines	2	1		6,000	72,000		100%		60%	40%			720	10,368	4,608	
DC Cell	2	6		22,500	45,000		100%		60%	40%			450	6,480	2,880	
WP Decontamination	1	0.5		1,800	43,200		100%		60%	40%			432	6,221	2,765	
Hot Support	5	2		30,600	183,600		100%		60%	40%			1,836	26,438	11,750	
WTB Washdown																
Floor Areas	1	12		25,000	45,000		100%		60%	40%			450	6,480	2,880	
WHB Items																
Assembly Xfer Lines																
Incoming Casks	430		0%		0	10%	100%	20%	48%	32%			0	0	0	
Outgoing Casks	430		50%		135,912	10%	100%		80%	20%			1,359	26,095	4,349	
DPC Overpacks	410		50%		93,499	10%	100%		80%	20%			935	17,952	2,992	
Pool Tooling & Misc.	200		100%	200	40,000		100%					100%				16,000
Pool Yokes	40	6	100%	400	32,000		100%					100%				12,800
DC, Top Edge	410		100%	50	20,500		100%				100%		410			
DC, Full	410		100%		186,998		100%		80%	20%			1,870	35,904	5,984	
Canister Xfer Lines																
Incoming Casks	159		0%		0	10%	100%	20%	48%	32%			0	0	0	
Outgoing Casks	159		8%		6,000	10%	100%		80%	20%			60	1,152	192	
Fixtures & Misc.	10		0%	400	0											
DC Handling																
Collars	1146		10%	200	22,920		100%		90%	10%			229	4,951	367	
Total:													11,600	182,000	56,700	28,800

Typically, compactible waste (rags, paper, and plastic) accounts for about 70% of generated solid LLW (Assumption 4.3.7). Therefore, the total compactible waste volume is:

21,800 Ft^3/Yr / 0.7 = 31,100 Ft^3/Yr

Adding to this the quantity of solid LLW generated in decontamination and washdown operations from Table 7.2-4, the total compactible waste volume is:

31,100 Ft^3/Yr + 11,600 Ft^3/Yr = 42,700 Ft^3/Yr.

With a 20% margin, (Assumption 4.3.6) the volume is:

42,700 Ft^3/Yr * 1.2 = **51,200 Ft^3/Yr Compactible Solid LLW**

The amount of non-compactible waste produced per year can be calculated from the volume produced per arriving cask (Assumption 4.3.8) and the number of casks in year 2026 (589):

15 Ft^3/Cask * 589 Casks/Yr = 8,840 Ft^3/Yr.

With a 20% margin the volume is:

8,840 Ft^3/Yr * 1.2 = **10,600 Ft^3/Yr Non-Compactible Solid LLW**

The final component of solid LLW, spent ion-exchange resin, is estimated (Assumption 4.3.9) to be 2,245 Ft^3/Yr from the WHB and 85 Ft^3/Yr from the WTB, on a 58.7 wt% water basis (Assumption 4.3.13), for a total of 2,330 Ft^3/Yr.

In summary, operations in the WHB and WTB are anticipated to produce the secondary LLW volumes shown on Table 7.2-5, which follows:

Table 7.2-5
Secondary Waste Generation Rate Estimate (Summary)

Waste Stream:	Waste Rate
Recyclable Aqueous (Gal/Yr)	182,000
Chemical Aqueous (Gal/Yr)	56,700
Compactible Solid Waste (Ft^3/Yr)	51,200
Non-Compactible Solid (Ft^3/Yr)	10,600
Spent Resin Slurry (Ft^3/Yr) (58.7 wt% water basis)	2,330

7.3 WASTE TREATMENT SYSTEM EVALUATION

As stated in Section 7.2 of this design analysis, the current waste treatment system conceptual design configuration includes the following:

1. Classification and segregation of aqueous secondary LLW streams as recyclable aqueous or chemical aqueous waste.

2. Treatment of aqueous recycle streams via filtration, evaporation, and ion-exchange, with grouting of evaporator bottoms.

3. Grouting of chemical waste streams.

4. Classification of solid secondary LLWs, followed by sorting, shredding, compaction, and grouting.

In order to determine the potential impact of revised secondary waste rates on the waste system configuration, it is necessary to compare the old and new rates. This rate comparison is presented in Table 7.3-1, along with the calculated percentage increase or decrease in estimated waste generation rate in comparison to the previous, 1995 estimate.

As shown in Table 7.3-1, the largest differences between the waste rate estimates are in the volume of recyclable aqueous waste, which is over twice the volume of the 1995 estimate, the volume of chemical aqueous waste, at nearly twice the previous volume, and the spent resin volume, which is nearly six times the volume of the previous estimate. The large increase in

Table 7.3-1
Secondary Waste Rate Comparison

Waste Stream:	1995 Rate Estimate	1997 Rate Estimate	Percent Change
Recyclable Aqueous (Gal/Yr)	75,100	182,000	+142%
Chemical Aqueous (Gal/Yr)	66,400	56,700	-15%
Compactible Solid Waste (Ft^3/Yr)	26,790	51,200	+91%
Non-Compactible Solid (Ft^3/Yr)	8,986	10,600	+18%
Spent Resin (Ft^3/Yr) (58.7% water)	400	2,330	+483%

both the aqueous waste streams is attributable to significant increases in the frequency of floor washdown in the WHB as well as the size (floor area) of the WHB, while the spent resin volume increase is due primarily to the addition of fuel assembly handling pools to the WHB design. It should be noted that the spent resin volume represents a small fraction of the total volume of solid waste treated (4%), and therefore has a small impact on the total volume of solid waste to be treated.

Although the increased secondary waste rates will require adjustments in waste treatment system equipment capacities, the base configuration is still justified. Had the rates been significantly reduced, certain treatment steps, such as super-compaction or evaporation, might not have been justified in the updated conceptual design. The existing conceptual configuration of the waste treatment system can be justified based on the reduction in treated waste volume achieved.

7.4 MATERIAL BALANCE

The waste rates developed in Section 7.3 of this report define the feed stream rates to the WTB. In this section of the design analysis, the streams resulting from each of the individual processing steps within the WTB will be defined, and data developed which describes these streams. This information will be presented in the form of a material balance table presented as part of the PFDs. The table will describe the flow and conditions of selected streams within the waste treatment system, and each stream will be assigned a number keyed to the PFDs.

7.4.1 Liquid Waste Streams

Stream 101 - Recyclable Water LLW from WHB

This stream represents the total flow of recyclable liquid LLW from the WHB to the WTB for treatment. This stream flow rate is derived from the data in Table 7.2-4 by subtracting WTB flow from the total as follows:

(182,000 Gal/Yr - 6,480 Gal/Yr) = 176,000 Gal/Yr.

Adding a 20% margin:

176,000 Gal/Yr * 1.2 = **211,000 Gal/Yr**

This stream is mostly water, is at ambient temperature, and has an assumed density of 66.5 Lb/Ft^3 (Per Assumption 4.3.17).

Stream 102 -Recyclable Water LLW from RH-TK-109 (WTB)

This stream represents the flow of recyclable aqueous waste from the WTB. For the purposes of this conceptual design, the floor area of the WTB is assumed to be 80% larger than the previous conceptual design. From Table 7.2-4, the flow of recyclable aqueous waste from the WTB in stream 102 is 6,480 Gal/Yr (including the 80% increase). With a 20% margin, the flow rate of this stream is:

6,480 Gal/Yr * 1.2 = **7,780 Gal/Yr**

The presumed conditions of this stream are the same as for stream 101.

Stream 103 -Total Recyclable Aqueous LLW

This stream is the sum of streams 101 and 102:

211,000 Gal/Yr +7,780 Gal/Yr = **219,000Gal/Yr**

Stream 104 - Aqueous Chemical LLW from the WHB

From the data in Table 7.2-4, the flow rate of this stream is:

(56,700 Gal/Yr - 2,880 Gal/Yr) = **53,800** Gal/Yr.

Adding a 20% margin the flow rate is:

53,800 Gal/Yr * 1.2 = **64,600Gal/Yr.**

This stream is at ambient conditions and has an assumed density of 64 Lb/Ft^3 (per Assumption 4.3.17).

Stream 105 - Floor Drain (Chemical) LLW from the RH-TK--109 (WTB)

From Table 7.2-4, the flow rate of this stream is 2,880 Gal/Yr. Adding a 20% margin the flow rate is:

2,880 Gal/Yr * 1.2 = **3,460 Gal/Yr**

This stream is at ambient conditions and has an assumed density of 66.5 Lb/Ft^3.

Stream 106 -Total Aqueous Chemical LLW

This stream is the sum of streams 104 and 105:

64,600 Gal/Yr + 3,460 Gal/Yr = **68,100 Gal/Yr.**

The volume fraction of stream 104 in this combined stream is:

64,600 Gal/Yr / (68,100 Gal/Yr) = 0.949

The density of this stream is, then:

$0.949 * 64.0\ Lb/Ft^3 + (1 - 0.949) * 66.5\ Lb/Ft^3 = 64.1\ Lb/Ft^3$

Stream 107 -Aqueous Chemical LLW to RH-TK-108

The average annual flow rate of this stream is the same as for stream 106, as are the conditions. Design the WTB to operate in a batch mode, 6 hours a day, 235 days per year (Assumption 4.3.1). Therefore, the volume of liquid handled per batch is:

68,100 Gal/Yr / 235 Days/Yr = **290Gal/Batch**

This stream will be pumped in a batch mode to processing. Allow 30 minutes to pump the batch volume to TK-108 (Assumption 4.3.10). Therefore, the flow rate in GPM is:

290 Gal/Batch / 30 Min = **9.7 GPM**.

Stream 108 -Aqueous Recyclable LLW to RH-FL-101-A/B

The average annual flow rate of this stream is the same as stream 103, as are the conditions. Design the WTB to operate in a batch mode, 6 hours a day, 235 days per year (Assumption 4.3.1). Therefore, the volume of liquid handled per batch is:

219,000 Gal/Yr / 235 Days/Yr = **932 Gal/Batch**

Allow this stream to be pumped in a batch mode for processing. Allow 60 minutes to pump the batch volume through the filter (Assumption 4.3.10). Therefore the flow rate in GPM is:

932 Gal/Batch / 60 Min = **15.5 GPM**

Stream 109 - Filtrate from RH-FL-101 A/B

For the purpose of this conceptual design, neglect the volume of suspended solids removed from this stream. The flow rate of this stream is then the same as the tank feed rate, stream 108, which is 219,000 Gal/Yr or 15.8 GPM. The batch size is also the same as stream 108 at 932 Gal/Batch.

Assume a filtrate density of 65.3 Lb/Ft^3, including dissolved solids (Assumption 4.3.17).

Stream 110 - Recyclable LLW to RH-V-101 (Evaporator)

Charge the batch evaporator continuously over a 3.5 hour evaporation period (Assumption 4.3.12). Therefore, the flow rate of evaporator feed is:

932 Gal/Batch / 3.5 hours = 266 Gal/Hr

266 Gal/Hr / 60 Min/Hr = **4.4GPM**

This stream is at ambient conditions.

Stream 111 -Evaporator Overhead Condensate

Set the overhead rate of the evaporator to 90% of the feed rate (Assumption 4.3.12). Therefore, the overhead rate is:

4.4 GPM * 90/100 = **4.0 GPM**

Evaporator overhead is accumulated over the 3.5 hour evaporation period. Therefore, the overhead condensate batch is:

4.0 GPM * 60 Min/Hr * 3.5 Hr = **840Gals**

This stream is water, with a density of 62.4Lb/Ft^3 (Assumption 4.3.17). Assuming that cooling water is available at a maximum cold water temperature of 97°F, and a 10°F temperature approach on the overhead condenser (Assumption 4.3.12), the condensate temperature is:

97°F + 10 = 107°F

Stream 112 -Evaporator Bottoms to RH-TK-108

The bottoms remaining in the evaporator after the evaporation period are equal to the difference between the feed batch volume and the overhead condensate volume:

932 Gal/Batch - 840 Gal/Batch = **92 Gal/Batch**

Allow 10 minutes to pump out these bottoms (Assumption 4.3.10). Therefore, the bottoms rate is:

92 Gal/Batch / 10 Min = **9.2 GPM**

Assume this stream to be cooled to 130°F prior to discharge from the evaporator (Assumption 4.3.12).

The assumed density of this stream is 80.9 Lb/Ft^3

Stream 113 - Ion-Exchange Unit Feed

Allow 180 minutes (3 hours) of processing time for the ion-exchange operation (Assumption 4.3.10). The volumetric flow rate of this stream is then the batch volume in stream 111 divided by the feed time:

840 Gal/Batch / 180 Min = **4.7 GPM**

The conditions of this stream are the same as stream 111.

Stream 114 - Recyclable Water to Tank RH-TK-107 A/B

This stream is the same as stream 113.

Stream 115 - Spent Ion-Exchange Resin

From Assumption 4.3.13, the annual volume of 58.7 wt% water spent resin from the WTB is 85 Ft^3/Yr. This is the dewatered resin. For this stream, assume the resin is slurried at 10 wt% resin, then dewatered prior to disposal. Estimate the density of 10% slurry to be 50 Lb/ Ft^3, and the density of 58.7 wt% water resin to be 32.5 Lb/ Ft^3 (Assumption 4.3.13).

The spent resin volume flow is:

85 Ft^3/Yr * 32.5 Lb/ Ft^3 = 2,760 Lb/Yr 58.7 wt% Water Resin

2,760 Lb/Yr * (1-0.587) = 1,140 Lb/Yr Resin

1,140 Lb/Yr Resin / 0.1 = **11,400 Lb/Yr 10% Resin Slurry**

The volume of 10% resin slurry is, then:

11,400 Lb/Yr / 50 Lb/ Ft^3 = **228 Ft^3/Yr 10% Resin Slurry**

228 Ft^3/Yr * 7.481 Gal/ Ft^3 = **1,710 Gal/Yr 10% Resin Slurry**

This resin is changed out on a monthly basis. Therefore, the volume/batch is:

1,710 Gal/Yr / 12 = 143 Gal/Batch

The transfer time for this batch would then be 15 minutes (per Assumption 4.3.10). The required pump capacity is:

143 Gal/Batch / 15 Min = 9.5 GPM

Stream 116 - Aqueous Chemical Waste from TK-108

This stream is liquid chemical waste which has been PH adjusted, and is the sum of streams 107 and 112:

290 Gal/Batch + 92 Gal/Batch = 382 Gal/Batch

There are 235 batches per year and, per the Chemical Engineers' Handbook, Reference 5.13, pg. 1-24, 1 Ft^3 = 7.481 Gal. Therefore:

382 Gal/Batch / 7.481 Gal/Ft^3 * 235 Batches/Yr = **12,000 Gal/Yr Aqueous Chemical Waste**

This stream is at ambient conditions.

The estimated density of this stream can be derived from the component stream densities.

290 / 382 = 0.759 Volume fraction stream 107

92 / 382 = 0.241 Volume fraction stream 112

The combined stream density is:

0.759 * 64.0 Lb/Ft^3 +0.241 * 80.9 Lb/Ft^3 = 68.1 Lb/Ft^3

Allowing 90 minutes to process the batch volume (per Assumption 4.3.10), the flow rate of this stream is:

382 Gal/Batch / 90 Min. = **4.2 GPM**

Stream 117- Grouted Chemical LLW Drums

The mass flow of stream 116 is:

382 Gals/Batch / 7.481 Gal/ Ft^3 (per Reference 5.13, p. 1-24) * 68.1 Lb/Ft^3 = 3,480 Lb

Per Assumption 4.3.14, the liquid-to-Portland cement ratio is 0.45 (i.e., 0.45 Lb liquid per 1 Lb Portland cement). Therefore, the Portland cement required is:

3,480 / (0.45/(0.45 + 1.0)) * (1 / (0.45 + 1.0)) = 7,730 Lb Portland Cement

The total solidified mass is then:

7,730 Lb Portland cement + 3,480 Lb waste = 11,200 Lb Grouted Waste

At a Portland cement density of 196 Lb/ Ft^3 per Reference 5.13, pg. 3-90, the concrete volume is:

11,200 Lb / 196 Lb/ Ft^3 * 7.481 Gal/ Ft^3 = 427 Gal

Assuming 80% of the available volume of a 55-gallon waste drum is usable (per Assumption 4.3.14), the number of drums produced per day is:

427 Gal / (55 * 80/100) = **9.7 Drums/Day Grouted Waste**

or

235 * 9.7 = **2,280 Drums/Year**

The weight per drum is approximately:

55 * 0.8 / 7.481 Gal/ Ft^3 * 196 Lb/ Ft^3 = **1,153 Lb**

Stream 118 - Dry Portland Cement to Drums

From the previous stream, the Portland cement required per batch is 7,730 Lb per day. The number of drums per day is 9.7. Therefore, the average mass of Portland cement added to each drum is:

7,730 / 9.7= **797 Lb Portland Cement/Drum**

The estimated density of loose Portland cement is 94 Lb/ Ft^3, per Reference 5.13, pg. 3-90.

Stream 119 - Recyclable Water from Resin Dewatering

The gravity filtration system (dewatering station) is fed with resin slurry at 10% resin content, and produces a dewatered resin stream with a 58.7 wt% water content. The excess water is returned to TK-102 via this stream.

From stream 203, 46,800 Gal/Yr of 10% spent resin are processed. This is equivalent to 313,000 Lb/Yr of spent 10 wt% resin slurry. The quantity of water in this slurry is:

313,000 Lb/Yr * 0.9 = 282,000 Lb/Yr Water

The amount of resin is:

313,000 Lb/Yr - 282,000 Lb/Yr = 31,000 Lb/Yr Dry Resin

The water in the dewatered 58.7 wt% water resin is:

31,000 Lb/Yr / (1-0.587) * .587 = 44,000 Lb/Yr Water

The excess water is the difference in these water flows:

282,000 Lb/Yr -44,000 Lb/Yr = **238,000 Lb/Yr Water**

The density of water at these conditions is approximately 62.4 Lb/ Ft^3 (per Assumption 4.3.17).

The annual volume of this stream is:

238,000 Lb/Yr / 62.4 Lb/ Ft^3 * 7.481 Gal/ Ft^3 = **28,500 Gal/Yr Water**

This resin is transferred out of the dewatering unit once per month (per Assumption 4.3.13). Allow 60 minutes to perform this operation (per Assumption 4.3.10). The volumetric flow rate is then:

238,000 Lb/Yr / 12 Mo/Yr / 62.4 Lb/ Ft^3 * 7.481 Gal/ Ft^3 = 2,380 Gal/Mo

2,380 Gal / 60 Min = **40 GPM Recyclable Water**

7.4.2 Solid Waste Streams

Stream 201 - Non-Compactible Solid LLW Generated

From Table 7.2-5, the volumetric flow rate of this stream is 10,600 Ft^3/Yr.

At an estimated density of 10 Lb/Ft^3 (per Assumption 4.3.14), the mass flow rate of this stream is:

10,600 Ft^3/Yr * 10 Lb/Ft^3 = **106,000 Lb/Yr Non-Compactible Solid Waste**

Assuming that 80% of the available volume in a 55-gallon drum is usable (per Assumption 4.3.14), the number of drums required is:

10,600 Ft^3/Yr * 7.481 Gal/Ft^3 / (80/100 * 55) = **1,800 Drums/Yr Non-Compactible Solid Waste**

Stream 202 - Compactible Solid LLW

From Table 7.2-5, the volumetric flow rate of this stream is 51,200 Ft^3/Yr.

At an assumed density of 10 Lb/Ft^3 (per Assumption 4.3.14), the mass flow rate of this stream is:

51,200 Ft^3/Yr * 10 Lb/Ft^3 = **512,000 Lb/Yr Compactible Solid Waste**

The number of 55-gallon drums required annually is:

51,200 Ft^3/Yr * 7.481 Gal/Ft^3 / (0.8 * 55) = **8,700 Drums/Yr Compactible Solid Waste**

Stream 203 - Loaded Spent Resin Drums

This stream represents the total volume of spent resin from both the WHB (pool systems) and the WTB. The WTB spent resin flow was specified in stream 115.

From Assumption 4.3.9, the annual volume of spent resin from the WHB and WTB is 2,330 Ft^3/Yr (on a 58.7 wt% water basis). (This is the dewatered resin flow).

Assuming all spent resin is slurried at 10% water and using the same density assumptions outlined for stream 115, calculate the volume of spent resin at 10% resin:

2,330 Ft^3/Yr * 32.5 Lb/Ft^3 = 75,700 Lb/Yr dewatered 58.7% water Resin Slurry

75,700 Lb/Yr * (1-0.587) = 31,300 Lb/Yr Resin

31,300 Lb/Yr / 0.1 = 313,000 **Lb/Yr 10% Resin Slurry from the WHB and WTB**

The volume of this resin slurry is:

313,000 Lb/Yr / 50 Lb/Ft^3 = **6,260 Ft^3/Yr 10% Resin Slurry from the WHB and WTB**

6,260 Ft^3/Yr * 7.481 Gal/Ft^3 = **46,800 Gal/Yr 10% Resin Slurry from the WHB and WTB**

This resin is also changed out on a monthly basis. Therefore, the volume per batch is:

46,800 Gal/Yr / 12 = 3,900 Gal/Batch

The number of drums per year of this 10% slurry resin is:

46,800 Gal/Yr / (55 * 0.8) = **1,060 Drums 10% Resin per Year**

Stream 204 - Dewatered Spent Resin

This stream is 58.7 wt% water resin. From Assumption 4.3.9, the volume of this resin is 2,330 Ft^3/Yr. At an assumed density of 32.5 Lb/Ft^3 (per Assumption 4.3.13), the mass flow rate of this resin is:

2,330 Ft^3/Yr * 32.5 Lb/Ft^3 = **75,700 Lb/Yr Dewatered Spent Resin**

2,330 Ft^3/Yr * 7.481 Gal/Ft^3 = **17,400 Gal/Yr Dewatered Resin**

The number of drums produced in the peak waste year is:

2,330 Ft^3/Yr * 7.481 Gal/Ft^3 / (0.8 * 55) = **396 Drums per Year**

Stream 205 - Compactible Waste to Super-Compactor

This stream is stream 202, which has been compacted. The mass flow rate of this stream is the same as stream 202.

Estimate the density of the compacted waste to be 40 Lb/Ft^3 (Assumption 4.3.14). Therefore, the annual volume of compacted waste is:

515,000 Lb/Yr / 40 Lb/Ft^3 = 12,900 Ft^3/Yr

The number of drums per year is then:

12,900 Ft^3/Yr * 7.481 Gal/Ft^3 / (0.8 * 55) = **2,190 Drums/ Yr Compacted Waste**

Stream 206 - Dry Portland Cement

Dry Portland cement is used to grout non-compactible, compactible, and spent resin waste streams. Differing amounts of Portland cement are required for each waste stream.

a. For non-compactible waste: Assume that 90% of the annular space between 55-gallon and 85-gallon drums is grouted. Therefore, the quantity of grout is, at a cured density of 196 Lb/Ft^3, per Assumption 4.3.15:

   (85 gal - 55 gal)(90/100) / 7.481 Gal/Ft^3 * 196 Lb/Ft^3 = 707 Lbs Cured Grout per 85-gallon Drum

   Per stream 201, there are 1,800 drums of this waste per year. Therefore, the Portland cement mass per year is:

   707 Lb Grout/Drum *1,800 drums/year = 1,270,000 Lbs/Yr Grout

   From Assumption 4.3.14, the mass of dry Portland cement is:

   1,270,000 Lbs * (1 / (1+.45))= **876,000 Lbs/Yr Dry Portland Cement**

b. For spent resin, assume that the spent resin acts as filler only (i.e., only the annular area between 85 and 55 gallon drums requires grout). Therefore, the cured grout volume per drum is the same as above, 707 Lbs.

   Per stream 204, the annual quantity of dewatered resin drums is 396. Therefore, the cured grout mass is:

   396 drums/Yr * 707 Lbs/drum = 280,000 Lbs/Yr Cured Grout

   and:

   280,000 Lb/Yr * (1 / (1+.45)) = **193,000 Lb/Yr Dry Portland Cement**

c. For compactible waste, estimate that a super-compactor can achieve a volume reduction of 70%, per Assumption 4.3.14. Then three 55-gallon drums would reduce to:

   (55 Gal * 3) * (100-70)/100 = 50 Gal (At the same external diameter as a 55-gallon drum)

When overpacked in an 85-gallon drum, the weight of cured grout required is (using the previously cited Portland cement density):

(85 Gal - 50 Gal) / 7.481 Gal/ Ft^3 * 90/100 * 196 Lb/ Ft^3 = 825 Lb Cured Grout/Drum

The number of 55-gallon drums of compacted waste is 2,190, per stream 205. Therefore, the number of 85-gallon drums required is:

2,190 / 3 = 730 Drums

The weight of cured grout required is:

730 * 825 = 602,000 Lb/Yr Cured Grout

The dry Portland cement weight is:

602,000 Lb/Yr * (1 / (1+.45)) = **415,000 Lb/Yr Dry Portland Cement**

The total quantity of dry Portland cement is then:

876,000 Lb/Yr + 193,000 Lb/Yr + 415,000 Lb/Yr = **1,480,000 Lb/Yr Dry Portland Cement**

With an estimated loose Portland cement density of 94 Lb/ Ft^3,as previously cited, the volume of dry Portland cement is:

1,480,000 Lb/Yr / 94 Lb/ Ft^3 =**15,700 Ft^3/Yr Dry Portland Cement**

Stream 207 - 85-gallon Drums to Disposal

This stream consists of the sum of the grouted non-compactible, compactible, and spent resin drums.

From stream 205, 2,190 55-gallon drums of compactible solid waste are fed to the super-compactor. Three of these super-compacted drums are overpacked in each 85-gallon drum. Therefore, the number of 85-gallon drums of compacted, grouted solid waste is:

2,190 drums/Yr / 3 = 730 85-gallon Drums/Year

From stream 204, 396 55-gallon drums of spent resin are processed annually. The number of grouted 85-gallon drums of spent resin produced annually is also 396.

The total number of 85-gallon drums of solid grouted LLW produced annually is:

1,800 Drums/Yr grouted non-compactible LLW + 730 Drums/Yr + 396 Drums/Yr
= **2,930 Drums/Yr**

7.5 WASTE TREATMENT EQUIPMENT SIZING

In this section of the design analysis, the capacity requirements for major equipment will be established.

RH-TK-101 Chemical Liquid LLW Collection Tank

Size this tank for a minimum of one month holdup of the chemical waste stream (Assumption 4.3.11). The maximum annual chemical waste flow, from material balance stream 106, is 68,100 Gal/Yr. One month holdup would be:

68,100 Gal/Yr / 12 Mo/Yr = 5,680 Gal

Use a 7,000 gallon tank in order to provide operational flexibility.

RH-TK-102 Recyclable Liquid LLW Collection Tank

The maximum annual flow of liquid LLW, per material balance stream 103, is 219,000 Gal/Yr. Using the same philosophy as above, one month holdup (Assumption 4.3.11) would be:

219,000 Gal/Yr / 12 Mon/Yr = 18,300 Gal

Use a 20,000 gallon tank in order to provide operational flexibility.

RH-PU-101 A/B Chemical Waste Feed Pump

This stream flow, from material balance stream 107, is 9.7 GPM.

RH-PU-102 A/B Recyclable Waste Feed Pump

This stream flow, from material balance stream 108, is 15.5 GPM.

RH-FL-101 A/B Cartridge Filter

This filter is sized for the flow rate of stream 108, 15.5 GPM.

RH-TK-103 Evaporator Feed Tank

Size this tank to hold one daily batch of evaporator feed. This volume, per material balance stream 108, is 932 gallons. Use a 1,200 gallon tank.

RH-PU-103 A/B Evaporator Feed Pump

This stream flow, from material balance stream 110, is 4.4 GPM.

RH-V-101 Evaporator Package

This evaporator is sized to process one batch per day of recyclable waste. From material balance stream 110, the batch volume is 932 gallons. The thermal load in this evaporator is the sensible heat necessary to raise the feed temperature to the boiling point of water plus the latest heat required to vaporize 90% of the feed batch.

Assuming a feed water temperature of 70°F per Assumption 4.3.12 and a water average specific heat of 1.00 BTU/Lb-°F (Reference 5.13, Pg 3-129), the sensible heat load is:

932 Gal / 7.481 Gal/Ft^3 * 62.4 Lb/Ft^3 * 1 BTU/Lb-°F * (212-70) = 1,100,000 BTU

Per Reference 5.13, Pg 3-206, the latent heat of steam at 212°F is the difference between the steam enthalpy and the liquid enthalpy at 212°F:

Latent Heat @ 212°F = 1150.5 BTU/Lb - 180.17 BTU/Lb = 970.3 BTU/Lb

Therefore, the latent heat load is:

932 Gal / 7.481 Gal/Ft^3 * 62.4 Lb/Ft^3 * 90/100 * 970.3 BTU/Lb = 6,790,000 BTU

This heat addition is, per material balance stream 111, accomplished in 3.5 hours. Therefore, the evaporator heat rate is:

(6,790,000 BTU +1,100,000 BTU) / 3.5 Hr = 2,250,000 BTU/Hr

Allow a 20% duty margin:

2,250,000 BTU/Hr * 1.2 = **2,700,000 BTU/Hr**

RH-E-101 Overhead Condenser

The heat exchanger condenses the overhead recycle water vapor stream from the evaporator.

The volume flow of this stream, based on the calculations for RH-E-101, is:

932 Gal/3.5 Hrs = 266 Gal/Hr

266 Gal/Hr / 7.481 Gal/Ft^3 * 62.4 Lb/Ft^3 = 2,220 Lb/Hr Water Vapor

The latent heat load is:

2,220 Lb/Hr * 970.3 BTU/Lb = 2,150,000 BTU/Hr

Assuming the condensate is cooled to 100°F, the sensible heat load is:

2,220 Lb/Hr * 1.00 BTU/Lb-°F * (212°F - 100°F) = 249,000 BTU/Hr

Therefore, the total heat load on this condenser is:

2,150,000 BTU/Hr +249,000 BTU/Hr = **2,400,000 BTU/Hr**

RH-TK-104 Condensate Collection Tank

Assuming 90% condensate overhead (Assumption 4.3.12), size this tank to hold one batch of condensate (per Assumption 4.3.11):

932 Gal/batch * 0.9 = 839 Gal

Use a 1000 gallon tank.

RH-PU-104 A/B Ion-Exchange Unit Feed Pump

Per material balance stream 113, the pump capacity is 4.7 GPM.

RH-DM-101 Ion-Exchange Columns

Size the columns for the capacity of RH-PU-104 A/B, 4.7 GPM

RH-TK-105 Resin Feed Tank

Size this tank to hold one batch of slurried resin. Per material balance stream 115, the volume of one resin batch is 143 gallons. Install a 200 gallon tank.

RH-TK-106 Spent Resin Catch Tank

Size this tank to hold one spent resin batch. Use a 200 gallon tank, the same as for RH-TK-105.

RH-PU-105 A/B Resin Transfer Pump

Allowing 30 minutes time to transfer the resin batch from RH-TK-105, per Assumption 4.3.10, the required pump capacity is:

143 Gal / 30 Min = 4.8 GPM

RH-PU-106 A/B Spent Resin Transfer Pump

Size this pump the same as RH- PU-105 A/B, 4.8 GPM.

RH-TK-107 A/B Recycle Water Storage Tanks

Install parallel tanks to permit continued operation in the event of off-specification product water production in the ion-exchange unit.

Per material balance stream 114, one batch (daily) volume of recycle water is 840 gallons. Install sufficient tank capacity for one week of water production (per Assumption 4.3.11):

840 Gal/batch * 7 batches = 5,880 Gal/Tank. Use: 7,000 Gal. Total volume is 3,500 gallons per each tank, A and B.

RH-PU-107 A/B Recycle Water Supply Pump

These are the main recycle water supply pumps.

Per Table 7.2-4, the annual volume of recycle water produced, includin a 20% margin per Assumption 4.3.6, is:

182,000 Gal/Yr. * 1.2 = 218,000 Gal/Yr

This equates to:

218,000 Gal/Yr / 235 Days/Yr = 928 Gal/Day

Presume the bulk of this water originates from recycle water.

Also, grout production consumes significant amounts of recycle water. From material balance stream 206, the quantity of Portland cement used annually is 1,480,000 Lb/Yr. The liquid to Portland cement ratio is 0.45 per Assumption 4.3.14. Therefore, the recycle water used to produce the grout is:

1,480,000 Lb/Hr / (1 / (1 + 0.45)) * (0.45 / (1 + 0.45))= 666,000 Lb/Hr water

At 62.4 Lb/Ft^3, the water volume is:

666,000 Lb/Hr / 62.4 Lb/Ft^3 * 7.481 Gal/Ft^3 / 235 Days/Yr = 340 Gal/Day

Adding a 20% margin, the water volume is:

340 * 1.2 = 408 Gal/Day

Therefore, the total recycle water demand approximates:

928 + 408 = 1,336 Gal/Day

Assume this volume must be delivered in two hours time, per Assumption 4.3.10. Therefore, the pump capacity would be:

1,336 Gal/Day / 2 Hrs/Day / 60 Min/Hr = 11.1 GPM

Install an 11.1 GPM pump.

RH-TK-108 PH Adjustment Tank

Size this tank to allow PH adjustment of a batch of chemical liquid waste. Per material balance stream 107, a batch is 290 gallons. Install a 400 gallon tank.

RH-PU-109 A/B Treated Chemical Waste Transfer Pump

Per material balance stream 116, the required pump capacity is 4.2 GPM.

RH-TK-109 Floor Drain Collection Tank

This tank holds floor wash water and other aqueous waste from within the WTB. Size this tank to provide a 20% design margin, per Assumption 4.3.6, for the liquid volume shown on Table 7.2-4.

6,480 Gal/Yr * 1.2 = 7,780 Gal/Yr Recyclable Water

2,880 Gal/Yr * 1.2 = 3,460 Gal/Yr Chemical LLW

Size this tank to provide six weeks of holdup capacity per Assumption 4.3.11:

7,780 Gal/Yr * 6/52 = 898 Gals

Use a 1000 Gal Tank.

RH-PU-110 A/B Floor Drain Transfer Pump

Size this pump to empty the collection tank in two hours per Assumption 4.3.10. The required pump capacity is then:

898 Gal / 120 Min = 7.5 GPM

RH-PU-111 Sump Pump

Size this single pump at the same capacity as RH-PU-110 A/B, 7.5 GPM, in order to minimize the number of different pump sizes in the waste treatment system.

RH-PU-201 A/B Filtrate Transfer Pump

Per material balance stream 119, the pump capacity required is 40 GPM.

7.6 LINE SIZING

In this section of the design analysis the line sizes of major process lines within the secondary waste treatment system will be sized. For given pipe sizes, fluid flow rates and physical properties, the Darcy equation and Fanning friction factors will be used to establish the fluid velocity and pressure drop per unit of pipe length. Final selection of a given line size will be based on typical ranges of economic pipe diameters described in Reference 5.13, Page 5-32, Table 5-17. These criteria are reproduced in Table 7.6-1. A LOTUS 1.2.3 spreadsheet will be used as a computational tool to perform the calculations. An example computation will be performed to validate the spreadsheet results.

Table 7.6-1
Economic Fluid Velocities *

Density, Lb/Ft^3	100	62.4	50	1.0	0.1	0.075	0.01
Viscosity, Cp	1	1	1	0.02	0.02	0.02	0.02
Economic Velocity, Ft/Sec . .	6.5	7.4	7.9	31	61	67	122

* Turbulent Flow, Sch. 40 Steel Pipe

The Darcy (Fanning) equation is (Ref.5.13, Pg. 5-21, Eq. 5-52):

$F = (32 * f * L * q^2) / (\pi^2 * g_c * D^5)$

Where:

F = friction loss in specific energy (Ft-Lb_f / Lb_m) f = Fanning friction factor (dimensionless)

L = pipe (duct) length (Ft) D = pipe (duct) diameter (Ft)

q = volume rate of flow (Ft ^{3}/Sec) g_c = dimensional constant = 32.17 (Lb-Ft/Lb_f-Sec^2)

Also, the pressure loss is: F * ρ (Lb/ Ft$^{2)}$ where ρ is the fluid density in Lb/Ft^3

The friction factor is obtained from the nomograph (Ref.5.13, Pg. 5.22, Fig.5-26), based on N_{re} and pipe Relative Roughness:

Relative Roughness = ϵ / D where ϵ = pipe roughness = 0.00015 Ft. (Ref. 5.13, Pg. 5-21, Table 5-7), for commercial steel, and D is as defined above..

N_{re} = Reynolds No. = D * V * ρ / μ

and: V = fluid velocity (Ft/sec) ρ = density (Lb/Ft^3) μ = fluid viscosity (Lb/Ft-sec)

Example Calculation:

For a six inch (nominal) diameter, schedule 40 steel pipe, 100 Ft.in length, flowing 347 GPM of water at 70 °F, calculate the line loss.

The density of water at 20 °C (~70 °F) is near one g/ml (Ref. 5.14, Pg. 3-70, Table 3-45). Converting g/ml to Lb/Ft^3 (Ref. 5.14, Pp. 1-23 and 1-24, Table 1-6):

1.0 g/ml * 1.0 ml/cc * 62.43 = 62.43 Lb/Ft^3.

Calc. **q** = 347 GPM / (7.481 Gal/ Ft^3 * 60 Sec/Min) = **0.773 Ft^3/Sec.** (1 Ft^3 = 7.481 Gal. Per Ref. 5.13, p. 1-24, Table 1-6).

The mass flow rate is:

0.773 Ft^3 / Sec * 3,600 Sec/Hr = 173,775 Lb/Hr

From Reference 5.14, Pg. 6-46, Table 6-2, the inside diameter of a 6 In. Nominal diameter, Sch. 40 pipe is 6.065 In.

Calc. **D** = 6.065 In / 12 In/Ft = **0.5 Ft.** (1 Ft. = 12 In. Per Ref. 5.13, p. 1-27, Table 1-11.)

So: **F** = $(32 * 100 * 0.7732^2 * f) / (\pi^2 * 32.17 * 0.5^5)$ = **193 * f** [π =3.1416 per Reference 5.13, p. 2-3] and :

Δ**P** = 193 * 62.43 * f = **12000 * f** (PSI/Ft^2)

Calculate N_{re}:

The fluid velocity **V** is just the volume flow (Ft^3/Sec) divided by the flow area (Ft^2).

From Reference 5.14, Pg. 6-46, Table 6-2, the inside diameter of a 6 In. Nominal diameter, Sch. 40 pipe is 6.065 In.

The area is, $(\pi * D^2) / 4$ =

$\pi * (6.065/12)^2 / 4 = 0.201$ Ft^2. Therefore **V** = 0.7732 / 0.201 = **3.9 Ft/Sec.**

Per Ref. 5.14, p. 3-200, Table 3-267, the viscosity of water is 1.0 centipoise at 70 °F.

Convert from centipoises to Lb/Ft-Sec (Per Ref. 5.14, Pg. 1-27, Table 1-8), multiply by 0.000672.

Therefore, μ = 1.0 * 0.000672 = **0.000672 Lb/Ft-Sec**

Calculate N_{re} = D * V * ρ / μ = 0.5 * 3.9 * 62.43 / 0.000672 = **180,781**

Calculate Relative Roughness = ϵ / **D** = 0.00015 / 0.5 = **0.00030**

From Ref. 5.13, Pg. 5-22, Figure 5-26: for N_{re} = 180781 and ϵ / **D** = 0.00030, **f = 0.0044.**

Therefore: $\Delta P =$ **12000** * f = **12000** * 0.0044 = **52.8** (Lb/Ft^2)

To convert from Ft^2 to In^2 divide by $12^2 = 144$

So: $\Delta P =$ **52.8** / 144 = 0.367 Lb/In^2 (PSI).

This is for new, clean pipe. Allow a 20% margin for fouled pipe so:

ΔP = 0.367 * 1.2 = **0.44 Lb/In^2 (PSI) for this 100 Ft. pipe segment.**

The spreadsheet output for this pipe segment follows in Table 7.6-2, and shows a line loss of 0.45 PSI/ 100Ft. which is in close agreement with the results of the example calculation reported above.

Waste Treatment System Line Sizing

The material of construction of all of the lines will be stainless steel.

Stream 102 - Recyclable LLW from WTB

The capacity of pump RH-PU-110 A/B is 7.5 GPM per Section 7.5 of this report. Per material balance stream 102, the density of the stream is 66.5 Lb/Ft^3. Therefore, the mass flow rate of this stream is:

7.5 GPM / 7.481Gal/Ft^3 * 60 Min/Hr * 66.5 Lb/Ft^3 = 4,000 Lb/Hr

The viscosity of waste at these conditions is 1 Cp, per the example calculation.

Use a one inch Schedule 40 line, which will have a velocity of 3.1 FPS and a pressure drop of 2.8 PSI/100 Ft.

Stream 103 - Recyclable LLW Flow to RH-TK-102

From material balance stream 103, the volumetric flow rate of this stream is 219,000 Gal/Yr and the density is 66.5 Lb/Ft^3. The mass flow rate is then:

219,000 Gal/Yr / 7.481Gal/Ft^3 * 66.5 Lb/Ft^3 = 1,950,000 Lb/Yr

Size this drain line generously by assuming 1/12th of the annual flow is processed in a one to six hour work day. Therefore, this flow rate is:

1,950,000 Lb/Yr / 12 / 6 Hr = 27,000 Lb/Hr

A two inch Schedule 40 line will have a velocity of 5.2 FPS and a line loss of 3.0 PSI/100 Ft

Table 7.6-2
Example Line Sizing

DARCY SPREADSHEET VER 1.106

Add-ins:

FLUOR DANIEL PALS DARCY FLOW - VER 10.4W

File Name:

O:\M&O\MCFEELY\DEMOPALS.WK4

Client:	U.S. DOE	Date:	06/25/97
Plant:	CRWMS	Area/Unit:	/
Contract:	04580827	By/Ck'd:	SHM / BEK
Revision:	0	Sheet:	1 OF 1
		Approved:	

Line Number	1			
Service	Pool Water			
P&ID Frame				
Tag Number				
Stream Number				
Preliminary Line Number				
Case Name	Example Calculation			

	Units	INPUT	CALC'D	INPUT	CALC'D	INPUT	CALC'D	INPUT	CALC'D
FLUID PROPERTIES									
Phase (V/L)		L							
Flow	lb/hr	173775.0							
Density (If not entered for vapor, calc from MW,P,T,Z)	lb/ft³	62.43	62.43						
Viscosity	cP	1.000							
Molecular Weight (Used to calc vapor density)									
Operating Pressure (Used to calc vapor density)	psia								
Operating Temperature (Used to calc vapor density)	°F								
Upstream Elevation	ft								
Downstream Elevation	ft								
Compressibility (Used to calc vapor density)									
Cp/Cv (Used to calculate sonic velocity)									
PIPE PROPERTIES									
Nominal Diameter/Actual ID	in	6.00	6						
Schedule (If not entered, entry above is assumed to be ID)									
Roughness	ft	0.00015		0.00015		0.00015		0.00015	
Frictional Design Margin (ex. 1.2= 20% margin)		1.2		1.2		1.2		1.2	
FLOW CHARACTERISTICS									
Velocity	ft/s		3.94						
Sonic Velocity	ft/s								
Reynold's Number			182898						
Friction Factor (Moody)			0.01791						
Delta P/100 ft * FDM	psi		0.45						
FITTING AND LINE DATA									
Straight Length	ft	100.0							

	Units	L/D Values	Qty	Delta P	Qty	Delta P	Qty	Delta P	Qty	Delta P
SR 45°	psi	14.61		0.00						
SR 90°	psi	20		0.00						
SR 180°	psi	30.79		0.00						
LR 45°	psi	9.91		0.00						
LR 90°	psi	14		0.00						
LR 180°	psi	22.18		0.00						
Tee (thru run)	psi	20		0.00						
Tee (thru branch)	psi	60		0.00						
Gate Valve	psi	8		0.00						
Ball Valve (Full Port)	psi	3		0.00						
Butterfly Valve (Requires Dia. Shown for E25)	psi	45		0.00						
Globe Valve	psi	340		0.00						
Swing Check Valve	psi	100		0.00						
Additional Cv (Enter Cv in Qty column)	psi			0.00						
Additional Cv (Enter Cv in Qty column)	psi			0.00						
Additional K (Enter K in Qty column)	psi			0.00						
Upstream Reducer/Expander (Enter Upstream ID in Qty column)										
(Enter length in Qty column)	psi	Press Ctl H		0.00						
Downstream Reducer/Expander (Enter Downstream ID in Qty column)										
(Enter length in Qty column)	psi	Press Ctl H		0.00						
Total frictional losses from fittings * FDM	psi			0.00						
Total frictional losses from line * FDM	psi			0.45						
Total frictional losses * FDM	psi			0.45						
Static delta P (- indicates pressure gain)	psi			0.00						
Total delta P including FDM	psi			0.45						

Line 105 - Chemical Floor Drain Pumpout From RH-TK-109

This line is sized the same as RH-TK-102, or one inch.

Line 106 - Total Chemical LLW to RH-TK-101

From material balance stream 106, the annual volumetric flow rate of this stream is 68,100 Gal/Yr. As was done for line 103, size this line for 1/12th the annual flow in six hours.

68,100 Gal/Yr / 7.481Gal/Ft^3 * 64.0 Lb/Ft^3 = 583,000 Lb/Yr

583,000 Lb/Yr / 12 / 6 Hrs = 8,100 Lb/Hr

A two-inch Schedule 40 line will yield a velocity of 1.6 FPS and a pressure drop of 0.3 PSI/100 Ft.

Line 107 - Chemical Waste Pumpout From RH-TK-101

Size this line for the flow rate of pump RH-PU-101 A/B.

The capacity of this pump is 9.7 GPM. Therefore:

9.7 GPM * 60 Min/Hr / 7.481Gal/Ft^3 * 64 Lb/Ft^3 = 5,000 Lb/Hr

A one inch Schedule 40 line size yields a velocity of 4.0 FPS and a line loss of 4.3 PSI/100 Ft

Line 108 - Recyclable LLW Pumpout From RH-TK-102

Size this line for the flow rate of pump RH-PU-102 A/B.

The capacity of this pump is 15.5 GPM. Therefore:

15.5 GPM * 60 Min/Hr / 7.481 Gal/Ft^3 * 66.5 Lb/Ft^3 = 8,270 Lb/Hr

A two inch line size yields a velocity of 1.6 FPS and a line loss of 0.3 PSI/100 Ft.

Line 109 - Filtrate to RH-TK-103

Size this line the same as line 108, or two inches.

Line 110 - Filtered LLW Pumpout to EV-101

This line is sized for the capacity of pump RH-PU-103 A/B, which is 4.4 GPM. The mass flow rate is:

4.4 GPM * 60 Min/Hr / 7.481Gal/Ft^3 * 65.3 Lb/Ft^3 = 2,300 Lb/Hr

A one inch Schedule 40 line yields a velocity of 1.8 FPS and a pressure drop of 1.0 PSI/100 Ft

Line 111 - Evaporator Condensate to RH-TK-108

From material balance stream 111, the flow rate of this stream is 4.0 GPM. The mass flow rate is:

4.0 GPM * 60 Min/Hr / 7.481Gal/Ft^3 * 62.4 Lb/Ft^3 = 2,000 Lb/Hr

A one inch Schedule 40 line yields a velocity of 1.6 FPS and a line loss of 0.8 PSI/100 Ft

Line 113 - Condensate to Ion-Exchange Unit RH-DM-101

This line is sized for the capacity of pump RH-PU-104 A/B, the ion-exchange unit feed pump. The pump capacity is 4.7 GPM. The mass flow rate is:

4.7 GPM * 60 Min/Hr / 7.481Gal/Ft^3 * 62.4 Lb/Ft^3 = 2,350 Lb/Hr

A one inch Schedule 40 line size yields a fluid velocity of 1.9 FPS and a pressure drop of 1.1 PSI/100 Ft

Line 114 Recyclable Water to RH-TK 107 A/B

The line is sized the same as line 113, or one inch.

Line 116 - Treated Chemical LLW to Drum Filling

Per material balance stream 116, the volumetric flow rate of this stream is 4.2 GPM at an assumed density of 68.1 Lb/Ft^3. The mass flow rate is then:

4.2 GPM * 60 Min/Hr / 7.481 Gal/Ft^3 * 68.1 Lb/Ft^3 = 2,290 Lb/Hr

Assuming the viscosity of this stream to be approximately one CP, a one inch Schedule 40 line yields a fluid velocity of 1.7 FPS and a pressure drop of 1.0 PSI/100 Ft.

The printouts from the spreadsheet follow as Table 7.6-3.

Table 7.6-3
Waste Treatment System Line Sizing

DARCY SPREADSHEET VER 1.106
Add-ins:
FLUOR DANIEL PALS DARCY FLOW - VER 1.0.4W

File Name:
O:\M &O\M CFEELY\LLWDP1.WK4

Client:	US DOE	Date:	06/26/97
Plant:	CRWMS	Area/Unit:	/
Contract:	04580827	By/Ck'd:	/
Revision:		Sheet:	1 OF 1
		Approved:	

Line Number										
Service			Aq. Chem Pumpout		Recyc LLW to TK-102		Reccy LLW Pumpout		Chem LLW to TK-102	
P&ID Frame			Fm TK-109				Fm TK-109			
Tag Number										
Stream Number										
Preliminary Line Number			102		103		105		106	
Case Name										
			INPUT	CALC'D	INPUT	CALC'D	INPUT	CALC'D	INPUT	CALC'D
FLUID PROPERTIES										
Phase (V/L)			L		L		L		L	
Flow	lb/hr		4000.0		27000.0		4430.0		8100.0	
Density (If not entered for vapor, calc from MW,P,T,Z)	lb/ft³		66.50	66.50	66.50	66.50	66.50	66.50	64.00	64.00
Viscosity	cP		1.000		1.000		1.000		1.000	
Molecular Weight (Used to calc vapor density)										
Operating Pressure (Used to calc vapor density)	psia									
Operating Temperature (Used to calc vapor density)	°F									
Upstream Elevation	ft									
Downstream Elevation	ft									
Compressibility (Used to calc vapor density)										
Cp/Cv (Used to calculate sonic velocity)										
PIPE PROPERTIES										
Nominal Diameter/Actual ID	in		1.00	1	2.00	2	1.00	1	2.00	2
Schedule (If not entered, entry above is assumed to be ID)										
Roughness	ft		0.00015		0.00015		0.00015		0.00015	
Frictional Design Margin (ex. 1.2= 20% margin)			1.2		1.2		1.2		1.2	
FLOW CHARACTERISTICS										
Velocity	ft/s			3.06		5.17		3.39		1.61
Sonic Velocity	ft/s									
Reynold's Number				25260		85253		27975		25576
Friction Factor (Moody)				0.02838		0.022		0.028		0.026
Delta P/100 ft * FDM	psi			2.75		3.07		3.33		0.34
FITTING AND LINE DATA										
Straight Length	ft									
		L/D Values	Qty	Delta P	Qty	Delta P	Qty	Delta P	Qty	Delta P
SR 45°	psi	14.61		0.00		0.00		0.00		0.00
SR 90°	psi	20		0.00		0.00		0.00		0.00
SR 180°	psi	30.79		0.00		0.00		0.00		0.00
LR 45°	psi	9.91		0.00		0.00		0.00		0.00
LR 90°	psi	14		0.00		0.00		0.00		0.00
LR 180°	psi	22.18		0.00		0.00		0.00		0.00
Tee (thru run)	psi	20		0.00		0.00		0.00		0.00
Tee (thru branch)	psi	60		0.00		0.00		0.00		0.00
Gate Valve	psi	8		0.00		0.00		0.00		0.00
Ball Valve (Full Port)	psi	3		0.00		0.00		0.00		0.00
Butterfly Valve (Requires Dia. Shown for E25)	psi	45		0.00		0.00		0.00		0.00
Globe Valve	psi	340		0.00		0.00		0.00		0.00
Swing Check Valve	psi	100		0.00		0.00		0.00		0.00
Additional Cv (Enter Cv in Qty column)	psi			0.00		0.00		0.00		0.00
Additional Cv (Enter Cv in Qty column)	psi			0.00	.	0.00		0.00		0.00
Additional K (Enter K in Qty column)	psi			0.00		0.00		0.00		0.00
Upstream Reducer/Expander (Enter Upstream ID in Qty column)										
(Enter length in Qty column)	psi	Press Ctl H		0.00		0.00		0.00		0.00
Downstream Reducer/Expander (Enter Downstream ID in Qty column)										
(Enter length in Qty column)	psi	Press Ctl H		0.00		0.00		0.00		0.00
Total frictional losses from fittings * FDM	psi			0.00		0.00		0.00		0.00
Total frictional losses from line * FDM	psi			0.00		0.00		0.00		0.00
Total frictional losses * FDM	psi			0.00		0.00		0.00		0.00
Static delta P (- indicates pressure gain)	psi			0.00		0.00		0.00		0.00
Total delta P including FDM	psi			0.00		0.00		0.00		0.00
NEXT DIAMETER SMALLER (See Note 1)										
Nominal Diameter	in									
Schedule (If not entered, above is assumed to be ID)										
Pipe Inside Diameter	in									
Velocity	ft/s									
Delta P/100 ft * FDM	psi									
Total Frictional Losses * FDM	psi			0.00		0.00		0.00		0.00
NEXT DIAMETER LARGER (See Note 1)										
Nominal Diameter	in									
Schedule (If not entered, above is assumed to be ID)										
Pipe Inside Diameter	in									
Velocity	ft/s									
Delta P/100 ft * FDM	psi									
Total Frictional Losses * FDM	psi			0.00		0.00		0.00		0.00

Note 1: Next larger and next smaller results are estimates and may NOT be accurate when reducer/expander used. Check results with full calculation in this case.

Revised: 24 Jan 1996

Table 7.6-3, continued
Waste Treatment System Line Sizing

DARCY SPREADSHEET VER 1.108

Add-ins:

FLUOR DANIEL PALS DARCY FLOW - VER 1.0.4W

File Name:

C:\CRWMS\DESANALS\LLWDA\LLWDP2.WK4

Client: U.S. DOE
Plant: CRWMS
Contract: 04580827
Revision:

Date: 06/25/97
Area/Unit: /
By/Ck'd: /
Sheet: 1 OF 1
Approved:

Line Number										
Service			Chem LLW Pumpout				Filtrate to TK-103			
P&ID Frame			Fm TK-101							
Tag Number										
Stream Number			107		108		109		110	
Preliminary Line Number										
Case Name										
			INPUT	CALC'D	INPUT	CALC'D	INPUT	CALC'D	INPUT	CALC'D
FLUID PROPERTIES										
Phase (V/L)			L		L		L		L	
Flow	lb/hr		5000.0		8270.0		8270.0		2300.0	
Density (If not entered for vapor, calc from MW,P,T,Z)	lb/ft³		64.00	64.00	66.50	66.50	66.50	66.50	65.30	65.30
Viscosity	cP		1.000		1.000		1.000		1.000	
Molecular Weight (Used to calc vapor density)										
Operating Pressure (Used to calc vapor density)	psia									
Operating Temperature (Used to calc vapor density)	°F									
Upstream Elevation	ft									
Downstream Elevation	ft									
Compressibility (Used to calc vapor density)										
Cp/Cv (Used to calculate sonic velocity)										
PIPE PROPERTIES										
Nominal Diameter/Actual ID	in		1.00	1	2.00	2	2.00	2	1.00	1
Schedule (If not entered, entry above is assumed to be ID)										
Roughness	ft		0.00015		0.00015		0.00015		0.00015	
Frictional Design Margin (ex. 1.2 = 20% margin)			1.2		1.2		1.2		1.2	
FLOW CHARACTERISTICS										
Velocity	ft/s			3.98		1.58		1.58		1.79
Sonic Velocity	ft/s									
Reynold's Number				31575		26113		26113		14525
Friction Factor (Moody)				0.02750		0.026		0.026		0.031
Delta P/100 ft * FDM	psi			4.33		0.34		0.34		1.02
FITTING AND LINE DATA										
Straight Length	ft									
		L/D Values	Qty	Delta P	Qty	Delta P	Qty	Delta P	Qty	Delta P
SR 45°	psi	14.61		0.00		0.00		0.00		0.00
SR 90°	psi	20		0.00		0.00		0.00		0.00
SR 180°	psi	30.79		0.00		0.00		0.00		0.00
LR 45°	psi	9.91		0.00		0.00		0.00		0.00
LR 90°	psi	14		0.00		0.00		0.00		0.00
LR 180°	psi	22.18		0.00		0.00		0.00		0.00
Tee (thru run)	psi	20		0.00		0.00		0.00		0.00
Tee (thru branch)	psi	60		0.00		0.00		0.00		0.00
Gate Valve	psi	8		0.00		0.00		0.00		0.00
Ball Valve (Full Port)	psi	3		0.00		0.00		0.00		0.00
Butterfly Valve (Requires Dia. Shown for E25)	psi	45		0.00		0.00		0.00		0.00
Globe Valve	psi	340		0.00		0.00		0.00		0.00
Swing Check Valve	psi	100		0.00		0.00		0.00		0.00
Additional Cv (Enter Cv in Qty column)	psi			0.00		0.00		0.00		0.00
Additional Cv (Enter Cv in Qty column)	psi			0.00		0.00		0.00		0.00
Additional K (Enter K in Qty column)	psi			0.00		0.00		0.00		0.00
Upstream Reducer/Expander (Enter Upstream ID in Qty column) (Enter length in Qty column)	psi	Press Ctl H		0.00		0.00		0.00		0.00
Downstream Reducer/Expander (Enter Downstream ID in Qty column) (Enter length in Qty column)	psi	Press Ctl H		0.00		0.00		0.00		0.00
Total frictional losses from fittings * FDM	psi			0.00		0.00		0.00		0.00
Total frictional losses from line * FDM	psi			0.00		0.00		0.00		0.00
Total frictional losses * FDM	psi			0.00		0.00		0.00		0.00
Static delta P (- indicates pressure gain)	psi			0.00		0.00		0.00		0.00
Total delta P including FDM	psi			0.00		0.00		0.00		0.00
NEXT DIAMETER SMALLER (See Note 1)										
Nominal Diameter	in									
Schedule (If not entered, above is assumed to be ID)										
Pipe Inside Diameter	in									
Velocity	ft/s									
Delta P/100 ft * FDM	psi									
Total Frictional Losses * FDM	psi			0.00		0.00		0.00		0.00
NEXT DIAMETER LARGER (See Note 1)										
Nominal Diameter	in									
Schedule (If not entered, above is assumed to be ID)										
Pipe Inside Diameter	in									
Velocity	ft/s									
Delta P/100 ft * FDM	psi									
Total Frictional Losses * FDM	psi			0.00		0.00		0.00		0.00

Note 1: Next larger and next smaller results are estimates and may NOT be accurate when reducer/expander used. Check results with full calculation in this case.

Revised: 24 Jan 1996

Table 7.6-3, continued
Waste Treatment System Line Sizing

DARCY SPREADSHEET VER 1.106
Add-ins:
FLUOR DANIEL PALS DARCY FLOW - VER 1.0.4W

File Name:
C:\CRWMS\DESANALS\LLWDA\LLWDP3.WK4

Client:	U.S. DOE	Date:	06/25/97
Plant:	CRWMS	Area/Unit:	/
Contract:		By/Ck'd:	/
Revision:		Sheet:	1 OF 1
		Approved:	

Line Number					
Service		Recyc. LLW Cond.			Treated Chem LLW
P&ID Frame		Fm. E-101			To Drum Filling
Tag Number					
Stream Number					
Preliminary Line Number		111	113	114	116
Case Name					

	Units	L/D Values	INPUT	CALC'D	INPUT	CALC'D	INPUT	CALC'D	INPUT	CALC'D
FLUID PROPERTIES										
Phase (V/L)			L		L		L		L	
Flow	lb/hr		2000.0		2350.0		2350.0		2290.0	
Density (If not entered for vapor, calc from MW,P,T,Z)	lb/ft^3		62.40	62.40	62.40	62.40	62.40	62.40	68.10	68.10
Viscosity	cP		1.000		1.000		1.000		1.000	
Molecular Weight (Used to calc vapor density)										
Operating Pressure (Used to calc vapor density)	psia									
Operating Temperature (Used to calc vapor density)	°F									
Upstream Elevation	ft									
Downstream Elevation	ft									
Compressibility (Used to calc vapor density)										
Cp/Cv (Used to calculate sonic velocity)										
PIPE PROPERTIES										
Nominal Diameter/Actual ID	in		1.00	1	1.00	1	1.00	1	1.00	[illegible]
Schedule (If not entered, entry above is assumed to be ID)										
Roughness	ft		0.00015		0.00015		0.00015		0.00015	
Frictional Design Margin (ex. 1.2= 20% margin)			1.2		1.2		1.2		1.2	
FLOW CHARACTERISTICS										
Velocity	ft/s			1.63		1.92		1.92		1.71
Sonic Velocity	ft/s									
Reynold's Number				12630		14840		14840		1446[illegible]
Friction Factor (Moody)				0.03197		0.031		0.031		0.03[illegible]
Delta P/100 ft * FDM	psi			0.83		1.11		1.11		0.97
FITTING AND LINE DATA										
Straight Length	ft									
		L/D Values	Qty	Delta P	Qty	Delta P	Qty	Delta P	Qty	Delta P
SR 45°	psi	14.61		0.00		0.00		0.00		0.00
SR 90°	psi	20		0.00		0.00		0.00		0.00
SR 180°	psi	30.79		0.00		0.00		0.00		0.00
LR 45°	psi	9.91		0.00		0.00		0.00		0.00
LR 90°	psi	14		0.00		0.00		0.00		0.00
LR 180°	psi	22.18		0.00		0.00		0.00		0.00
Tee (thru run)	psi	20		0.00		0.00		0.00		0.00
Tee (thru branch)	psi	60		0.00		0.00		0.00		0.00
Gate Valve	psi	8		0.00		0.00		0.00		0.00
Ball Valve (Full Port)	psi	3		0.00		0.00		0.00		0.00
Butterfly Valve (Requires Dia. Shown for E25)	psi	45		0.00		0.00		0.00		0.00
Globe Valve	psi	340		0.00		0.00		0.00		0.00
Swing Check Valve	psi	100		0.00		0.00		0.00		0.00
Additional Cv (Enter Cv in Qty column)	psi			0.00		0.00		0.00		0.00
Additional Cv (Enter Cv in Qty column)	psi			0.00		0.00		0.00		0.00
Additional K (Enter K in Qty column)	psi			0.00		0.00		0.00		0.00
Upstream Reducer/Expander (Enter Upstream ID in Qty column)										
(Enter length in Qty column)	psi	Press Ctl H		0.00		0.00		0.00		0.00
Downstream Reducer/Expander (Enter Downstream ID in Qty column)										
(Enter length in Qty column)	psi	Press Ctl H		0.00		0.00		0.00		0.00
Total frictional losses from fittings * FDM	psi			0.00		0.00		0.00		0.00
Total frictional losses from line * FDM	psi			0.00		0.00		0.00		0.00
Total frictional losses * FDM	psi			0.00		0.00		0.00		0.00
Static delta P (- indicates pressure gain)	psi			0.00		0.00		0.00		0.00
Total delta P including FDM	psi			0.00		0.00		0.00		0.00
NEXT DIAMETER SMALLER (See Note 1)										
Nominal Diameter	in									
Schedule (If not entered, above is assumed to be ID)										
Pipe Inside Diameter	in									
Velocity	ft/s									
Delta P/100 ft * FDM	psi									
Total Frictional Losses * FDM	psi			0.00		0.00		0.00		0.00
NEXT DIAMETER LARGER (See Note 1)										
Nominal Diameter	in									
Schedule (If not entered, above is assumed to be ID)										
Pipe Inside Diameter	in									
Velocity	ft/s									
Delta P/100 ft * FDM	psi									
Total Frictional Losses * FDM	psi			0.00		0.00		0.00		0.00

Note 1. Next larger and next smaller results are estimates and may NOT be accurate when reducer/expander used. Check results with full calculation in this case.

Revised: 24 Jan 1996

8. CONCLUSIONS

This design analysis presents an update of the secondary waste treatment system conceptual design. The previous system design was based on the predominant use of MPCs at the repository as well as dry handling of transportation casks. This conceptual design update is based on the predominant use of DPCs, as well as both wet handling and dry handling waste handling systems. This design update also includes a re-assessment of secondary waste volumes. The revised secondary waste rates show a significant increase in the volume of recyclable aqueous liquid and spent resin volumes. These increased waste rates translate to increased equipment capacity in the secondary waste processing system, but do not support modification of the basic process configuration. The concept of recycling of aqueous LLW and grouting of aqueous chemical LLW and solid LLW is retained in this conceptual design update.

In the course of preparation of this conceptual design update, several aspects of secondary waste treatment have been identified which require additional investigation. The scope of this design analysis precluded investigation of these issues during preparation of this design analysis. These areas are discussed below:

1. Both the current and previous conceptual designs of the waste treatment system include some redundant processing systems. Specifically, separate Portland cement grouting systems are provided for liquid chemical LLW as well as for solid LLW. Combining these grouting systems should be examined with a view toward reducing or eliminating equipment redundancy.

2. The current secondary waste handling system is conceived to operate essentially in a batch mode, 235 days per year, 6 hours per day. It may prove more efficient and cost effective to process secondary wastes either continuously or in larger batches. These alternative operating modes should be examined.

3. The batch operating modes proposed for both liquid and solid LLW processing should be examined using a simulation tool such as WITNESS Visual Interactive Simulation Software, in order to confirm the anticipated throughput of the waste handling system. This is particularly important because of the batch (discreet) operating mode of the solid LLW processing system.

The WITNESS model might also prove to be a valuable tool in investigating item numbers.

9. ATTACHMENTS

ATTACHMENT	DESCRIPTION
I	Waste Treatment System Sketches

WASTE TREATMENT SYSTEM SKETCHES

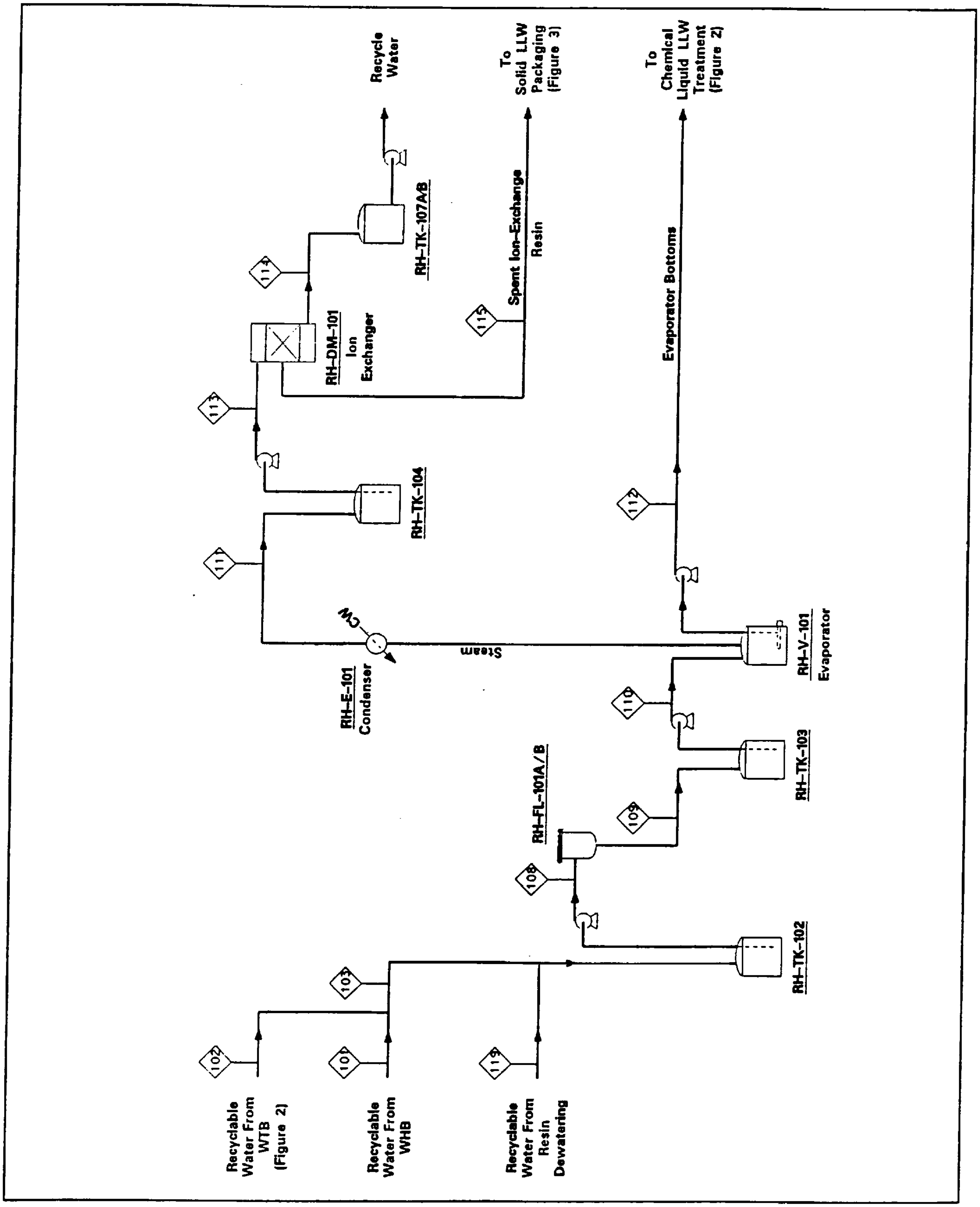

Figure 1 Recyclable Liquid LLW Treatment

WASTE TREATMENT SYSTEM SKETCHES

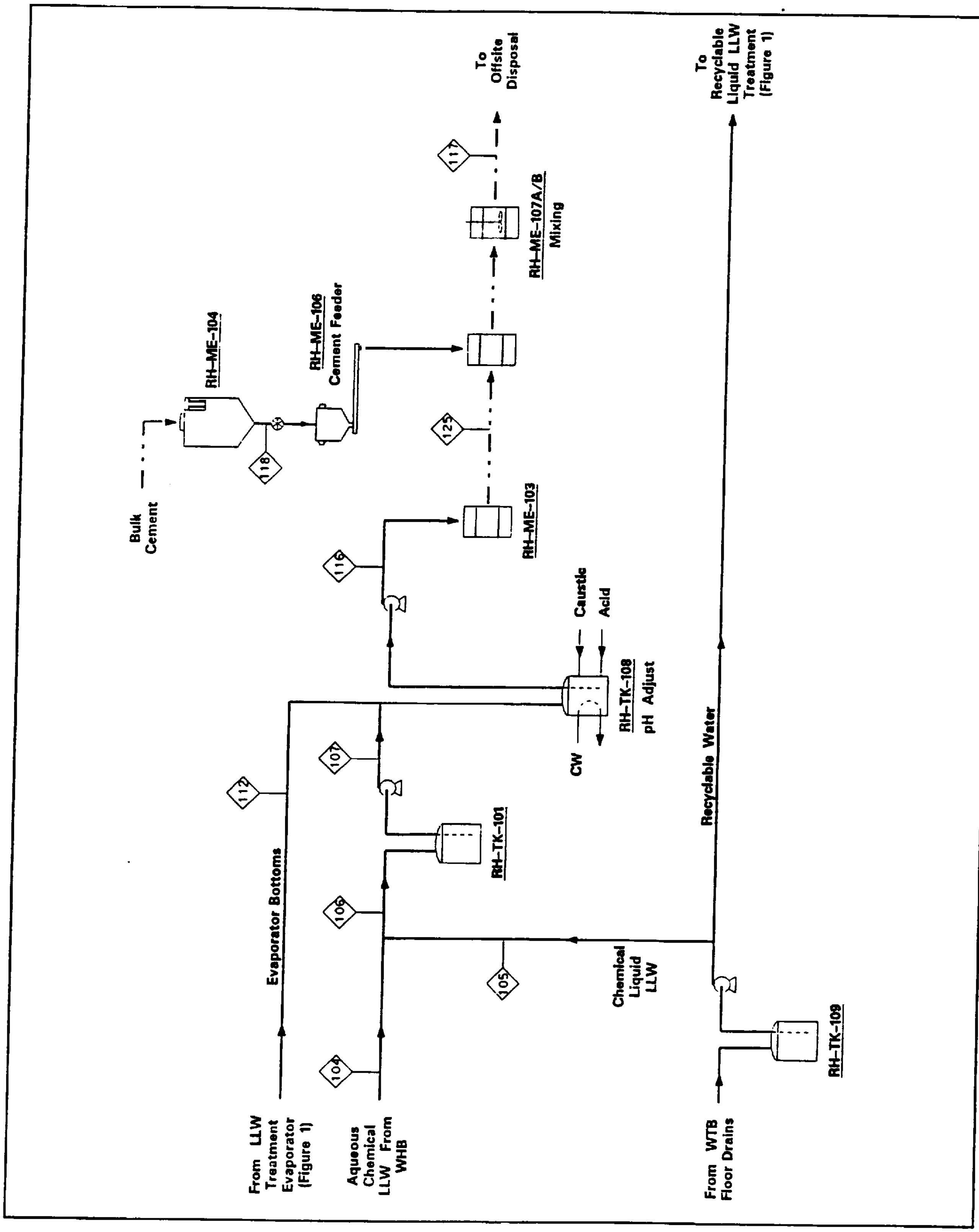

Figure 2 Chemical Liquid LLW Treatment

WASTE TREATMENT SYSTEM SKETCHES

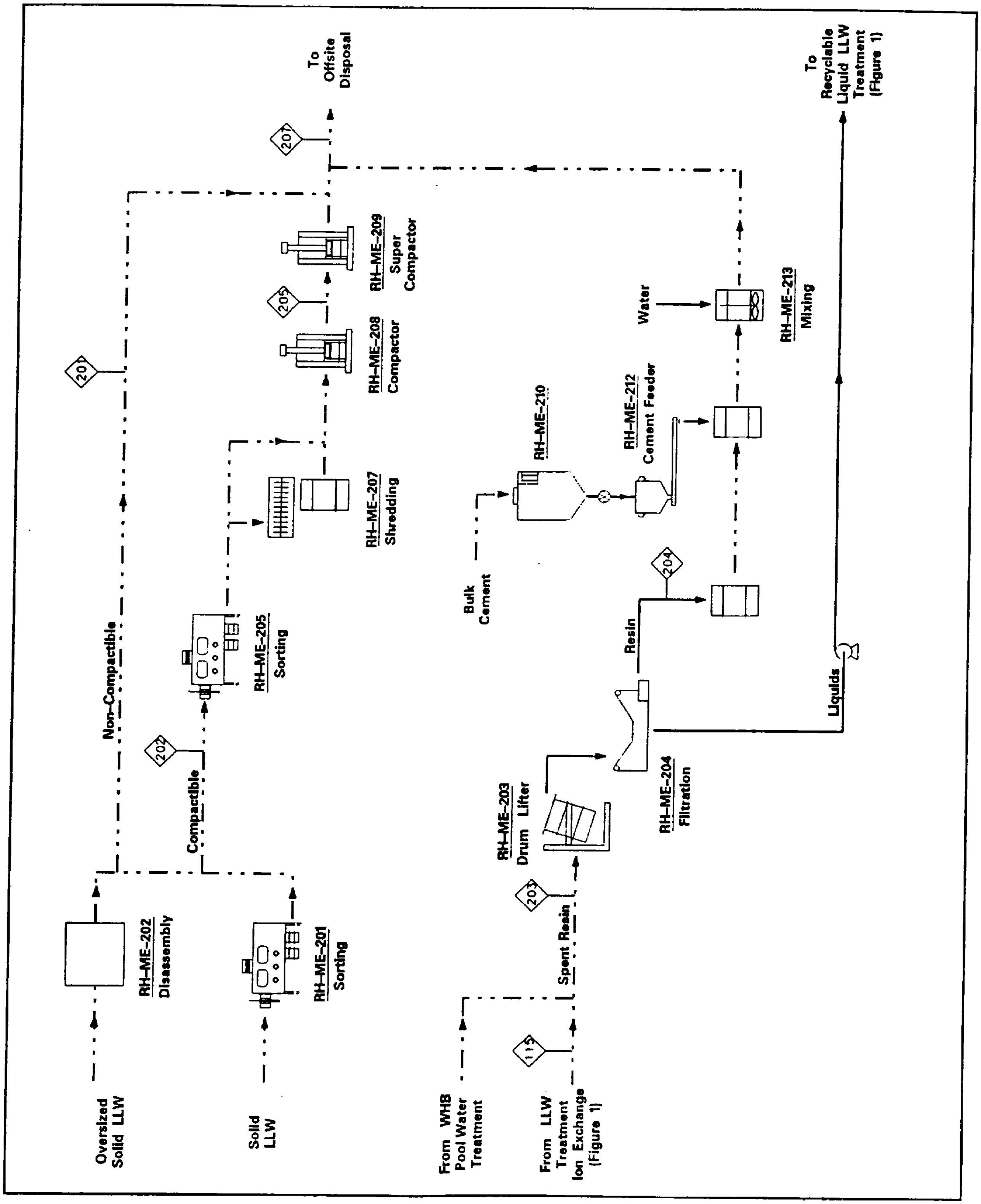

Figure 3 Solid LLW Packaging